Engineering
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The Engineer.

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VOL. CXLIII.—No. 3718] LONDON: FRIDAY EVENING, APRIL 15, 1927 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

The Director-General, India Store Department, Branch No. 15, Belvedere-road, Lambeth, S.E.1, invites TENDERS for—
1. 942 Pairs DISC WHEELS and AXLES.
2. 400 Pairs STEEL TYRES, Flanged and Ring Fastened, for Railway Carriage and Wagon Wheels.

Tenders due on the 29th April, 1927, for No. 1, and on May 3rd, 1927, for No. 2.
Specifications and forms of Tender obtainable from the above at a fee of 5s. per set, which will not be returned. 5255

Civil Service Commission.
FORTHCOMING EXAMINATION.
PROBATIONARY ASSISTANT ENGINEERS in the Engineering Department of the Post Office (20-23, with extension in certain cases). Regulations and particulars are obtainable from the SECRETARY, Civil Service Commission, Burlington-gardens, London, W. 1, together with the form on which application must be made. The latest date for the receipt of application forms is 14th July. 5243

Royal Corps of Naval CONSTRUCTORS.
A COMPETITIVE EXAMINATION for a POST as PROBATIONARY ASSISTANT CONSTRUCTOR will be held at the Royal Naval College, Greenwich, during the first fortnight in July next.
The Regulations may be obtained from the SECRETARY OF THE ADMIRALTY (C.E. Branch), Whitehall, S.W. 1, to whom intending candidates must submit their names and full particulars of their educational and technical training and practical experience not later than the 30th April, 1927.
Candidates must be not more than 24 years of age on the 1st October next.
Applications for the Regulations should be accompanied by an addressed envelope.

PRIVATE STUDENTS OF NAVAL ARCHITECTURE.
In conjunction with the above Examination there will be a QUALIFYING EXAMINATION for the admission of Private Students of Naval Architecture to the Royal Naval College, Greenwich.
Applications for the Regulations should be made as in the case of the Examination for the post of Probationary Assistant Constructor (see above).
Private Students are required to pay a fee of £50 a session whilst at the College. 5261

Assistant Accountant REQUIRED by the GOVERNMENT of NIGERIA for the PUBLIC WORKS DEPARTMENT for two tours, each of 12 to 18 months' service, with possible permanency. Salary £400 a year, rising to £720. Outfit allowance of £60 on first appointment. Free quarters and passages. Liberal leave on full salary. Candidates, aged 25 to 35, must be of good education and address. They should have had experience in keeping cost accounts gained with a firm of public works contractors.—Apply at once by letter, stating age and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, mentioning this paper and quoting M/15300. IT IS USELESS FOR CANDIDATES WITHOUT THE EXPERIENCE SPECIFIED TO APPLY. 5233

Herbert Morris 1½ Ton TRAVELLING CRANE, power-driven in all three directions, with separate controllers situated in underslung cab, supply voltage 400 D.C., span 17ft. 7in., cross travel 13ft., lift 20ft., landing stage and access ladder, conductors and approximately 170ft. crane track to be included.
To be inspected at the Home Office Industrial Building, Horseferry-road, Westminster, S.W. 1.
Reply, CHIEF ENGINEER, H.M. Office of Works, Storey's-gate, S.W. 1. 5250

Armstrong College,
NEWCASTLE-UPON-TYNE.
(IN THE UNIVERSITY OF DURHAM.)

COURSES for the PASS DEGREE of B.Sc. and the HONOURS DEGREE of B.SC. in MECHANICAL, MARINE, CIVIL or ELECTRICAL ENGINEERING, MINING, METALLURGY, or NAVAL ARCHITECTURE. The curricula of the Pass Degree and the Honours Degree normally occupy periods of three and four years respectively, but candidates presenting evidence of sufficient previous training may be allowed to proceed to either Degree after two years' residence.

The engineering laboratories have recently been extended, and all Departments are equipped for advanced tutorial and research work.

Full particulars of the Courses may be had on application to
THE REGISTRAR,
Armstrong College,
5089 Newcastle-upon-Tyne.

Crystal Palace School of PRACTICAL ENGINEERING.
Founded 1872.
PRINCIPAL: MAURICE WILSON, M. Inst. C.E., F.S.E.
VICE-PRINCIPAL: F. C. P. LAWRENCE, M.S.E., A.M.I. Struct. E.
The NEW SESSION will COMMENCE on APRIL 27th. 5240

Northampton Polytechnic INSTITUTE,
ST. JOHN-STREET, LONDON, E.C. 1.
ENGINEERING DAY COLLEGE.
An ENTRANCE EXAMINATION in connection with the Engineering Day College of the above Polytechnic will be held on TUESDAY, APRIL 26th, 1927.
The Examination provides for admission at the commencement of the Autumn Term, 1927, and is designed to meet the convenience of intending students who desire to ascertain in advance their position in regard to admission.
Further information may be had on application to 5249 THE PRINCIPAL.

The Engineer

PRINCIPAL CONTENTS OF THIS ISSUE.
ARRANGED FOR CARD INDEXING.

Internal Combustion Locomotives.
(E. KITSON CLARK.) THE ENGINEER, 15-4-27.

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(MAURICE DEMOULIN.) THE ENGINEER, 15-4-27.

Paint Making Machinery—No. II.
THE ENGINEER, 15-4-27.

Determination of the Efficiency of an Exhaust Gas Boiler.
(G. COOK.) THE ENGINEER, 15-4-27.

America and Great Britain.
THE ENGINEER, 15-4-27.

Welded Repairs to a Melbourne Bridge.
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A New Switchgear Works.
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Characteristic Energy Diagram for an Oil Engine.
(W. E. DALBY.) THE ENGINEER, 15-4-27.

Institution of Naval Architects—No. II.
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PUBLIC NOTICES

Borough of Guildford.
(WATERWORKS EXTENSIONS UNDER GUILDFORD CORPORATION ACT, 1926.)
CONTRACT NO. 3.
SUPPLY AND LAYING OF 18in. AND 6in. CAST IRON MAINS.
The Corporation of Guildford are prepared to receive TENDERS for SUPPLYING and LAYING 2913 YARDS of 18in. and 594 YARDS of 6in. CAST IRON WATER MAINS with VALVES, TEES, SPECIALS, and all ACCESSORIES within the Borough area.
Copies of the form of contract, general conditions, specification of works, bill of quantities and form of Tender will be issued to a limited number of selected firms on or before Thursday, the 21st day of April, 1927.
Contractors willing to Tender are requested to write to that effect to the Consulting Engineer, Mr. Percy Griffith, M. Inst. C.E., F.G.S., 30, Victoria-street, Westminster, S.W. 1, not later than the date above mentioned.
Tenders must be delivered under seal at my office not later than 4 p.m. on Thursday, the 5th day of May, 1927.
The Corporation do not bind themselves to accept the lowest or any Tender.
C. H. WOOD,
Town Clerk.
Town Clerk's Office, Guildford,
13th April, 1927. 5248

State Electricity Commission
OF VICTORIA, AUSTRALIA,
22-32, WILLIAM-STREET, MELBOURNE, AUSTRALIA.
TENDERS are hereby INVITED for the MANUFACTURE, SUPPLY and DELIVERY for the Yallourn Brown Coal Works, Victoria, Australia, of 15,000 K.W. STEAM GENERATOR and ACCESSORIES in accordance with Specification No. 27/33.
Copies of Tender form, specification, &c., will be available upon application to:—
The Agent General for Victoria,
Victoria House, The Strand,
London, England.
CHARGE.—£1 1s. for three copies of Tender form, conditions of contract and specification complete. This charge will be returned in the event of a bona fide Tender being received. Extra copies 10s. each, not returnable.
PRELIMINARY DEPOSIT.—A preliminary deposit of 1 per cent. of total Tender price is to be lodged with Tender with a maximum of £100.
Tenders, on prescribed forms, properly endorsed and addressed, must be delivered at the office of the Commission, Melbourne, not later than 5th July, 1927.
The Commission does not bind itself to accept the lowest or any Tender.
R. LIDDELOW,
5176 Secretary.

PUBLIC NOTICES

Durham County Water Board.
The undermentioned PLANT installed at the Presser Pumping Station, about one mile south-east of Hunstanworth Village, Co. Durham, is offered FOR SALE, viz.:—
One Z.C. Type H.P. National Improved Otto Gas Engine, complete and fixed with Self-starter, Electric Ignition Friction Clutch, and One H Type Suction Gas Plant.
One 100 H.P. Oil Engine.
Two Sets of Pumps of the lift type, working barrel 16in. diameter, 5ft. stroke, with quadrants, gearing, and spear rods.
The dismantling and removal of the plant to be carried out by the purchaser at his own expense and risk.
Facilities will be given for the plant to be inspected on intimation being forwarded to the Board's Engineer, Mr. Henry Robinson, of Bishop Auckland.
Offers for the whole of the plant or any part of it to be forwarded to the Clerk to the Water Board at Darlington not later than 23rd April, 1927.
W. READ WARD,
Clerk to the Board.
25, Northgate, Darlington,
11th April, 1927. 5258

Port of Bristol Authority.
EXTENSION OF THE ROYAL EDWARD DOCK, AVONMOUTH.
CONSTRUCTION OF THE EASTERN ARM.
DREDGING.
The Port of Bristol Authority is prepared to receive TENDERS for DREDGING at the Eastern Arm of the Royal Edward Dock, Avonmouth.
On and after Tuesday, the 19th April, 1927, copies of the specification and contract drawing can be obtained from the undersigned on production of a receipt showing that a deposit of £5 has been paid. ALL CHEQUES MUST BE MADE PAYABLE to the "PORT OF BRISTOL AUTHORITY" and forwarded to the General Manager and Secretary, Dock Office, 19, Queen-square, Bristol. The deposit will be returned to bona fide tenderers after the receipt of the Tender with all the prescribed documents and drawings.
Tenders must be enclosed in a sealed envelope, endorsed "Tender for Dredging, Eastern Arm, Royal Edward Dock, Avonmouth," and addressed to the General Manager and Secretary of the Port of Bristol Authority, 19, Queen-square, Bristol, and must be delivered to him accompanied by all the prescribed documents and drawings before 10 a.m. on Wednesday, the 11th day of May, 1927.
The Port of Bristol Authority does not bind itself to accept the lowest or any Tender.
THOMAS A. PEACE,
Chief Engineer.
Chief Engineer's Office,
Avonmouth Docks, Bristol,
11th April, 1927. 5247

PUBLIC NOTICES

Metropolitan Water Board.
TENDERS FOR THE SUPPLY OF STORES, &c.
The Metropolitan Water Board invite TENDERS for the SUPPLY of the undermentioned STORES, &c., for the periods of 6 and 12 months, commencing 1st June, 1927:—
Tender No.
1. Bricks, Fire-bricks, Cement, &c.
8. Iron and Steel.
9. Bolts and Nuts, Screws, Files, Shovels, Steam Tubes, &c.
11. Repair of Meters.
12. Fuel Oil, Oils (Lubricating), Kerosene, Motor Spirit, Greases, Tallow, &c.
19. Small Iron, Brass, Gun-metal, and other Castings.
20. G.M. Stop Cocks and Ferrules, Outlets and Caps for Fire Hydrants.
22. Timber.
23. Maintenance of Weighing Machines.
Tenders must be submitted on the official forms, which may be obtained from the Chief Engineer on and after Monday, 11th April, 1927, by personal application at the Board's offices (Room 156) or upon forwarding a stamped addressed brief envelope.
Applicants should refer to the number of the Tender for which forms are required.
Tenders, enclosed in sealed envelopes, addressed to the Clerk of the Board, and endorsed in the manner indicated in the form of Tender, must be delivered at the offices of the Board (Room 122) not later than 11 a.m. on Friday, 29th April, 1927.
The Board do not bind themselves to accept the lowest or any Tender.
G. F. STRINGER,
Clerk of the Board.
Offices of the Board,
New River Head,
173, Rosebery-avenue, E.C. 1,
4th April, 1927. 5215

Metropolitan Water Board.
MAIN—ALBERT-ROAD TO BRECKNOCK-ROAD.
The Metropolitan Water Board invite TENDERS for the LAYING and JOINTING of approximately 2900 LINEAL YARDS of 36in. diameter CAST IRON WATER MAIN and CONNECTIONS, together with CONTINGENT WORKS, from Albert-road in the Metropolitan Borough of St. Pancras, to Brecknock-road, in the Metropolitan Borough of Islington, in the County of London.
The drawings and contract documents may be inspected without charge at the offices of the Board, Chief Engineer's Department (Room 201).
Forms of Tender, conditions of contract, specification and bills of quantities, together with drawings and a spare copy of the bills of quantities, may be obtained on and after the 20th April, 1927, from the Chief Engineer, on production of an official receipt for the sum of £10, which must be deposited with the Accountant to the Board and which will be returned on receipt of a bona fide Tender, accompanied by all the above-named documents and drawings (with the exception of the spare copy of the bills of quantities, which may be retained by the tenderer). Such payments and applications must be made between the hours of 10 a.m. and 4.30 p.m. (Saturdays, 10 a.m. and 12 noon). Cheques must be made payable to the Metropolitan Water Board and not to individuals.
Tenders, enclosed in sealed envelopes, addressed to the Clerk of the Board and endorsed "Tender for Main, Albert-road to Brecknock-road," must be delivered at the offices of the Board (Room 122) no later than 10 a.m. on Monday, the 9th May, 1927.
The Board do not bind themselves to accept the lowest or any Tender.
G. F. STRINGER,
Clerk of the Board.
Offices of the Board,
173, Rosebery-avenue, E.C. 1,
6th April, 1927. 5216

City of Leicester.
MECHANICAL ENGINEERING ASSISTANT.
APPLICATIONS are INVITED from qualified MECHANICAL ENGINEERS, who must be well versed in up-to-date methods and practice in regard to Engines, Boilers, Pumps and Machinery; competent to undertake inspections during construction and to carry out working tests, &c.; inspect and test Iron and Steel Work required for contracts; also to prepare drawings and specifications for machinery of all kinds.
Commencing salary £350 per annum (Grade F).
The position is an established post under the Local Government and Other Officers' Superannuation Act, 1922, and the successful candidate will be required to pass a medical examination and to contribute to the Fund.
Applications must be made upon the forms which may be obtained from me on receipt of a stamped foolscap envelope, and must be delivered not later than Saturday, April 30th next.
A. T. GOOSEMAN, M. Inst. C.E.,
City Engineer and Surveyor.
Town Hall, Leicester,
April 12th, 1927. 5257

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PUBLIC NOTICES

Brighton Intercepting and OUTFALL SEWERS BOARD.

APPLICATIONS are INVITED for the APPOINTMENT of a RESIDENT ENGINEER in connection with the Construction of the Sewer Outfall and Sea Wall at Portobello, near Brighton.

Probable duration of work about two years.

Salary Eight Guineas per week.

Applications, stating age and previous experience, with copies of three recent testimonials, should reach the undersigned not later than Monday, April 25th, 1927.

DAVID EDWARDS, M. Inst. C.E., F.S.I., Engineer to the Board.

Town Hall, Brighton, 8th April, 1927. 5234

London County Council.

DIVISIONAL ENGINEER (MECHANICAL) IN THE CHIEF ENGINEER'S DEPARTMENT.

The London County Council invites APPLICATIONS from qualified Mechanical Engineers for the POSITION of DIVISIONAL ENGINEER (MECHANICAL) in the Department of the Chief Engineer of the Council. Candidates who did not serve in H.M. Armed Forces during the Great War must be naturalborn British subjects. The scale of salary attaching to the position is £700 a year, rising by annual increments of £50 to £800 a year, and is at present subject to temporary additions on the Civil Service scale, fluctuating according to the cost of living. On the existing basis the total minimum remuneration is £913 17s. 6d., and the maximum £1023 8s. 11d. The next revision of the temporary additions will take place not later than 1st September, 1927.

Candidates must possess recognised qualifications as mechanical engineers and have occupied positions of responsibility in the conduct of work and the supervision and management of the staff of a drawing-office. Preference will be given to candidates who served or attempted to serve in H.M. Forces during the Great War.

Applications must be made on the official form, which contains particulars of the nature of the duties and conditions of appointment and copies of which may be obtained by sending a stamped addressed foolscap envelope, marked "Divisional Engineer (Mechanical)," to the Clerk of the Council, The County Hall, Westminster Bridge, S.E. 1. Forms must be returned not later than Tuesday, 10th May 1927. Canvassing disqualifies.

MONTAGU H. COX, Clerk of the London County Council.

5251

Madras Port Trust.

AN ASSISTANT MECHANICAL ENGINEER is REQUIRED for service under the Madras Port Trust, India; must possess a good general and technical education and hold either an Extra First Class or First Class Board of Trade Certificate as a Marine Engineer.

Candidates should not be more than 35 years of age (Public School men preferred), and must be qualified to supervise the maintenance and repair of the dredger, tugs, motor launches, hydraulic, electric and steam cranes and power plant, and locomotives and wagons, in use by the Port Trust. They should also have a knowledge of constructional steel work and electrical work.

SALARY.—Commencing at Rupees 650 per month and rising by annual increments of Rs. 33 1-3 to Rs. 950, with Rs. 60 house allowance or free quarters, and Provident Fund benefits.

TERMS.—A three years' agreement in the first instance, of which the first six months will be on probation, with first-class free passage to Madras and home again on satisfactory termination of services. Appointment will be subject to passing a strict medical examination.

Applications may be made by letter only and must contain a detailed record of candidates' career (with dates) in chronological order, including general and technical education, and must be received by the undersigned not later than 22nd April, 1927.

RENDEL, PALMER & TRITTON, 12/14, Dartmouth-street, Westminster, S.W. 1. 5235

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED, ASSISTANT in the London Office of a Firm of Combustion Engineers. Must be able to speak French fluently and have had some drawing-office experience. State age, salary, and experience. —Address, P3064, The Engineer Office. P3064 A

WANTED, CONTRACTORS' ENGINEER, Experienced in Public Works, to Take Charge of Road Contracts; age 30/40. Salary £450 rising.—Write, stating experience, to Box 11, c/o Mather and Crowther, Ltd., 10/13, New Bridge-street, E.C. 4. 5238 A

WANTED for Large Yorkshire Colliery, First-class MECHANICAL ENGINEER'S DRAUGHTSMAN. State age, wage required, and full details of eduction and experience, with copies of three recent references. First-class men only need apply.—Address, 5241, The Engineer Office. 5241 A

WANTED for MIDLAND DISTRICT, First-class CONSTRUCTIONAL ENGINEER, used to Colliery, Bridge, and general constructional work. Must be capable of taking out stresses, and taking charge of all office work, including estimating, costing, and general designing. Only practical and energetic men over 30 years of age need apply, giving full references and details of career which will be treated as confidential. State salary, and when at liberty. —Address, 5195, The Engineer Office. 5195 A

ASSISTANT ENGINEWRIGHT WANTED for a Large Yorkshire Colliery. State age, experience, and wage required, with copies of three recent references.—Address, 5242, The Engineer Office. 5242 A

ASSISTANT REQUIRED for the Preparation of Technical Data, Illustrations, Catalogues, &c., in connection with Industrial Instruments. Engineering experience essential. State age, experience, and salary required.—Address, P3072, The Engineer Office. P3072 A

CAPABLE and Experienced ENGINEER REQUIRED for Firm of Reinforced Concrete Engineers.—Address, stating full particulars of experience, age, and salary required, 5256, The Engineer Office. 5256 A

CONSTRUCTIONAL STEELWORK DESIGNER REQUIRED in London Office; able to produce Competitive Schemes of all classes quickly. Good knowledge of London Building Acts essential. Full particulars of experience, &c.—Address, 5271, The Engineer Office. 5271 A

ENGINEER WANTED for Chemical Factory in East London. Write, giving full particulars of experience, age, salary required, to "H. X.," c/o Street's, 6, Gracechurch-street, E.C. 3. 5259 A

HEATING ENGINEER.—WANTED IMMEDIATELY by prominent North Country Heating Engineers, first-class HEATING and VENTILATING ENGINEER, capable dealing with all classes and types of Heating and Ventilating Work. No shipbuilding draughtsman need apply.—Reply, stating experience, age, salary required, Box E271, Lee and Nightingale, Liverpool. P3065 A

THE NATIONAL BOILER AND GENERAL INSURANCE CO., Ltd., St. Mary's Parsonage, Manchester, REQUIRE ADDITIONAL INSPECTORS in the Lift and Crane Department. Applicants should be between 25 and 35 years of age and be prepared to reside in any part of the country; must be practical engineers with actual experience in construction, erection and repair of Lifts and Cranes; also must have recognised theoretical qualifications and be able to make dimensioned sketches. Duties include the examination and tests of all classes of lifts, cranes, and other lifting appliances. Salary to commence £260 per annum.—Apply in own handwriting, by letter only, marked "Lift and Crane Inspector," giving age, outline of practical training and experience, particulars of theoretical training, and copies of testimonials, to EDWARD G. HILLER, Chief Engineer and General Manager. 5244 A

SITUATIONS OPEN (continued)

MECHANICAL ENGINEER, Age 25-35, with Fair knowledge of French, experienced SALESMAN for Turbo Machinery (pumps, fans, compressors, steam turbines), WANTED by important French Firm to enter their London Agency.—Write to Mr. RIEDER, 50, Rue Fabert, Paris (7e), stating full particulars and salary. P3053 A

REPRESENTATIVES REQUIRED by Well-known Firm in the Midlands, manufacturing Electric Cranes and Lifts, for Manchester and District, Belfast and Dublin.—Address, stating experience and terms, 5198, The Engineer Office. 5198 A

AN Experienced DRAUGHTSMAN is REQUIRED for the Development of Printing Machinery. A knowledge of Off-set Work is essential. Give full particulars of experience and state age and salary required.—Address, 5232, The Engineer Office. 5232 A

WANTED, ARCHITECTURAL JUNIOR DRAUGHTSMAN, experienced and capable designer, and able to take out quantities. State age, experience, and salary required.—Address, 5264, The Engineer Office. 5264 A

CHIEF DESIGNER WANTED.—A Well-known FIRM of CRANE BUILDERS in the North of England DESIRE the SERVICES of a thoroughly experienced LEADING DRAUGHTSMAN for Cranes of all types and similar Engineering Work.

Only those capable of designing without supervision need apply.

A competent man will be assured of a permanent position and progressive salary.

State age, full details of experience, and when at liberty.

Address, 5236, The Engineer Office. 5236 A

DRAUGHTSMAN WANTED, Age About 30, capable of Designing Modern Coal and Coke Elevators and Conveyors, and with good experience in General Mechanical Details. State full particulars and salary required.—Address, 5202, The Engineer Office. 5202 A

DRAUGHTSMAN (Good Junior) for Temporary Position in Kent, experienced in Ferro-concrete and Structural Steel. Sound technical education essential.—Address, 5252, The Engineer Office. 5252 A

HEATING ENGINEER, DRAUGHTSMAN, Experienced in Central Heating Work; also JUNIOR WANTED for drawing-office.—Write, stating qualifications and salary, to HENRY HOPE and SONS, Ltd., 59, Berners-street, W. 1. 5265 A

EXPERIENCED DRAUGHTSMAN REQUIRED in the Manchester district for Internal Combustion Engines, special development. State age, experience, and salary required.—Address, 5263, The Engineer Office. 5263 A

JUNIOR DRAUGHTSMAN REQUIRED by Well-known Midland Firm of Electric Crane and Lift Manufacturers.—Address, stating age, experience, and salary, 5186, The Engineer Office. 5186 A

YOUNG JUNIOR DRAUGHTSMAN WANTED AT ONCE for Engineering Firm at Hendon.—Address, stating experience, wages and when free, 5239, The Engineer Office. 5239 A

SITUATIONS OPEN (continued)

LEADING DRAUGHTSMAN WANTED; Must be used to Machine Tool Designing and Construction and have had at least 4 years' shop experience; capable of taking entire responsibility of drawing-office.—Address, stating age, experience, and salary required, P3068, The Engineer Office. P3068 A

STRUCTURAL DRAUGHTSMAN REQUIRED by British firm in India; must have had good technical training, be able to Work Out Stresses, Prepare Designs, Estimates and Detail Drawings of Roof, Bridge and General Structural Steelwork; must be a bachelor, age 22 to 25.—Apply, stating age and particulars of experience, to Z.P. 120, care Deacon's Advertising Agency, Fenchurch-avenue, E.C. 3. 5270 A

WANTED, Practical Working TOOLROOM FOREMAN, experienced in making Press Tools and Dies.—Address, with full details, experience, and salary required, 5237, The Engineer Office. 5237 A

EXPERIENCED SHOP FOREMAN WANTED for important Mine in the Tropics. Must be good organiser and used to both fine and heavy work.—Write, stating age and giving full details of training and experience, to "LATHE," c/o J. W. Vickers and Co., Ltd., 24, Austin Friars, E.C. 2. 5260 A

PATTERNMAKERS.—Permanency for Capable Men. District rate.—Apply, F. J. SMITH, 2 and 2a, Wynyatt-street, Goswell-road, E.C. 1. 5151 A

SITUATIONS WANTED

AUTOMOBILE PRODUCTION ENGINEER, with 24 years' practical experience (past 5 years as assistant works manager), DESIRES responsible POSITION. Thoroughly experienced in organising all operations necessary in the production of complete cars. Available immediately.—Address, P3067, The Engineer Office. P3067 B

CIVIL ENGINEER OPEN to UNDERTAKE SETTING-OUT of WORKS. Contracts carried through by periodic visits. Water, Railway, Sewage, &c. &c.—Address, P3058, The Engineer Office. P3058 B

YOUNG ENGINEER (24), with Engineering College training (passed A.M.I. Mech. E. exam.) and 5 years' workshop experience, also considerable experience in motor car and motor cycle designing and experimental work, DESIRES progressive APPOINTMENT.—Address, P3044, The Engineer Office. P3044 B

DESIGNER DRAUGHTSMAN (25), Energetic, thorough training in mechanical engineering, aeronautics, testing, experimenting and research on aero-engines, D.I.C., pilot's A licence, DESIRES POSITION in active firm with preference for design, testing or research of high-speed Diesel and petrol engines or motor cars.—Address, P3023, The Engineer Office. P3023 B

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A PARTNER or PARTNERSHIP

or wish to buy or sell a

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HENRY BUTCHER, HALL & CO.,

63 & 64, CHANCERY LANE, LONDON, W.C. 2.

AN Old-Established Engineering Firm (Manchester District), well known all over the world, REQUIRES an ENERGETIC ENGINEER, with £10,000 to £20,000, to invest for new developments and to take an active interest in the management. State full particulars and experience.—Address, P3027, The Engineer Office. P3027 C

MISCELLANEOUS

AUTHORS DESIRING PROMPT PUBLICATION of their WORK should forward same Messrs. ARTHUR STOCKWELL, Ltd., 29, Ludgate-hill, London. Established 29 years. Advice free; 24-page booklet of Press commendations on application. 5267 I

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A Seven-Day Journal

National Certificates and Diplomas in Mechanical Engineering.

THE Council of the Institution of Mechanical Engineers has recently considered afresh the question of the relation of the educational standards implied in the National Certificate and Diploma in Mechanical Engineering, awarded by the Council in conjunction with the Board of Education, the Scottish Education Department and the Ministry of Education of Northern Ireland, and the standard required of candidates in the entrance examinations of the Institution. Taking into account the experience which has been gained during the past five years, the Council has now decided —subject to certain conditions being complied with— to extend to the ordinary certificate and the ordinary diploma the principle of recognition, which in 1923 was granted to holders of the higher certificate and the higher diploma, who wished to become candidates for election as students, graduates or associate members of the Institution. It has been decided that an ordinary national certificate will be accepted as exempting candidates from the examination papers in elementary mathematics and elementary mechanics of the studentship examination. An ordinary national diploma will also be accepted as exempting from such subjects of the studentship examination as in the opinion of the Council correspond to the subjects of final examination named in the diploma. The holders of combined ordinary and higher national certificates and diplomas in mechanical engineering will also be exempted from such subjects of Section A of the associateship examination as in the opinion of the Council correspond to the subjects covered in the final examinations for the ordinary certificate or ordinary diploma. In most cases such exemptions will include the applied mathematics paper, as both mathematics and mechanics are normally subjects of the final examination for the ordinary certificate and the ordinary diploma.

A White Star Motor Liner.

IT is announced that the White Star Line has placed with Harland and Wolff, Ltd., of Belfast, an order for a new motor liner for its New York passenger service. It is undestood that the new vessel will have a gross tonnage between 25,000 and 30,000 tons, and will thus be the largest British motor liner in existence. The new vessel will be propelled by Harland-B. and W. double-acting four-stroke cycle marine oil engines similar in design to those which have proved so successful in the Royal Mail liners Asturias and Alcantara. It may be recalled that when describing the latter ship in our issue of February 25th we commented on the low fuel consumption of this 22,180-ton liner, which works out at a figure of from 68 to 70 tons of fuel per twenty-four hours for all purposes when at sea and about 4 tons per day when in port. There is no doubt that similar economic figures will be obtained in the new White Star liner. The new ship will be the first in the White Star fleet to be propelled by marine oil engines. It is further understood that the White Star Line intends to build another liner of the "Olympic" type with a probable tonnage of 40,000 to 50,000 gross, towards which the Government of Northern Ireland has given a guarantee under the Loan Guarantee Act. As yet no particulars are forthcoming with regard to this proposal. We understand that both the hull and the machinery of the motor liner recently ordered will be constructed at Belfast and that a start with the laying of the keel will be made shortly after the Easter holidays.

Oil *versus* Coal.

AT the jubilee meeting of the Cunard Steamship Company, Ltd., which took place last week at Liverpool, Sir Thomas Royden, chairman of the company, made an interesting reference to the relative costs and operating expenses of oil and coal-burning ships. Most of the large Cunard liners are oil-burning vessels, and it is not surprising to learn that the oil fuel bill of that company is actually larger than the bill for fuel which is paid by the British Admiralty. After enumerating the advantages of oil, which are briefly summed up in the quick turn round obtained, the general cleanliness of the fuel and the reduced engine-room staff, Sir Thomas Royden went on to say that, against these great advantages the unfavourable cost of fuel oil compared with that of coal had to be considered. There were limits, he thought, to the price which a shipping company could afford to pay for oil fuel, and it was quite possible, he continued, that if the price of oil continued to rise the Cunard Company might be required to give serious consideration to a reversion to the use of coal, at any rate for a part of its fleet. There is among shipowners and marine engineers an increasing opinion that if oil fuel is to be made use of aboard ship it should be reserved for burning directly in the cylinders of oil engines or for raising steam in high-pressure boilers which would serve efficient geared turbine machinery. It is not unlikely that renewed attention will be given to the claims of coal in the near future, and the results obtained from mechanical stokers fitted to marine boilers and from powdered fuel plants for ship use will be awaited with interest.

Telephone Development.

SPEAKING at the seventh ordinary general meeting of the International Automatic Telephone Company a few days ago, the chairman, Sir Alexander Roger, remarked that the Telephone Development Association was continuing its efforts to assist the Government to popularise the telephone habit and to facilitate the expansion of the industry in Great Britain. In this connection it is noteworthy that a growth of only 1 per cent. in the number of subscribers involves nearly a million pounds' worth of business to the telephone industry as a whole. The number of telephones installed in this country on January 1st, 1926, was 1,366,562, and at the close of the year 1,477,000, representing an increase of 110,438 or 8·11 per cent., and credit must be given to the Telephone Development Association for having assisted in this substantial growth. This country is, however, still a long way behind many other nations in the matter of telephone developments. Without aspiring to the density of telephone traffic in America, this country should have at least double the present number of telephones in service. This increase would mean the expenditure of many millions of pounds and would afford employment to the various ramifications of the telephone industry for many years to come. An expanding telephone service means increasing employment and improved communications, and is consequently an aid both to social and business life.

The London County Council's Tramways.

ALTHOUGH the deficit on the working of the London County Council's tramways for the financial year ending March 31st last was not so great as it had been in the previous year, it was sufficiently high to be distinctly disquieting for the ratepayers of London, for it has to be met out of the rates. The amount is given as having been £114,629, but it is pointed out by the District Auditor in his report, which was made public early this week, that but for two important items which do not relate to the normal working of the undertaking during the year, the figure would have been in excess of £146,600. And that is not all! During the financial year 1926–27 the Council again took advantage of the permission of H.M. Treasury to defer payment of the part of the amount due for the repayment of loans incurred on capital account prior to March 31st, 1924, and subject to a twenty-five years' term for redemption. The amount withheld was approximately £300,000 so that the actual deficit was over £400,000, and it has to be remembered that repayment is only deferred, and that that £300,000 will have to be forthcoming some time. It is hardly to be wondered at, therefore, that the Auditor should remark that consideration of these figures and of other facts which he mentions "shows that the present position of the undertaking is not as satisfactory as could be wished, and the immediate future, pending the reduction of repayment charges upon the expiration of loan periods, must be regarded with some apprehension, because, unless early recovery takes place in its financial results, the resumption of provision for repayment of the twenty-five years' loans is likely to cause the burden on the rates to become more serious."

William Beardmore and Co, Ltd.

AT a meeting of the holders of the 8 per cent. notes of William Beardmore and Co., Ltd., which was held on Friday, April 8th, under the chairmanship of Mr. F. A. Szarvasy, it was agreed to postpone the payment of interest due on May 1st for a period of six months, before which date the advisory committee hoped to have definite proposals to place before the noteholders. As far as the preliminary investigations of the advisory committee were concerned, Mr. Szarvasy stated that it was felt that the company had been both honestly and efficiently managed in the past and that the main causes of the present difficult financial position were the great changes after the war and the slackness of trade and shortage of orders which had followed since 1920. The accounts had not yet been published for 1925, but it was anticipated that they would show a loss of about £250,000 and a further substantial loss for 1926 would be recorded, which was largely caused by the coal strike and its attendant troubles. Since January the position had improved and there was a bigger volume of orders on hand, which were in the main of a profitable nature. Mr. Szarvasy referred to the advisory committee which had been appointed, the function of which was to advise the directors as to the best methods of overcoming the present difficulties and later on regarding the reorganisation of the company's capital. Although the situation, he said, was one which would require care and attention, he was of the opinion that, even given only moderately favourable trade conditions in the future, the company would be in a position to take advantage of them and to regain a considerable measure of prosperity. The firm has, it may be added, recently secured a valuable contract for wheels and axles for the South African Railways and Harbour Administration, which work will be undertaken at Parkhead. At Mossend new orders were recently put in hand for rails for the London and North-Eastern Railway and the State Railways of Esthonia.

The Berlin Airway Station.

IN view of the rebuilding of London's Terminal Air Port at Croydon, interest attaches to the new airway station at Berlin, which is being constructed at the Tempelhof Aerodrome. The scheme, which has been undertaken by the Berlin Airport Company, provides for the erection of a large central building with east and west wings. The east wing will provide accommodation for the administration offices and also two wireless rooms and a telegraph room so that communication can be maintained with other aerodromes and with machines in actual flight. The central portion of the building which was opened on Sunday last, April 10th, forms the station itself and comprises waiting rooms, ticket offices, luggage and Customs department, and a post office, which is connected by a pneumatic tube with the city of Berlin. In the west wing accommodation will be provided for some 4000 people when flying displays are held. It will be entirely separate from the passenger department, and there will be dining rooms, tea rooms, and a roof garden restaurant and terrace, as well as mess rooms for the staff. The arrival and departure platforms are railed off and the machines can now come up to them on a wide stretch of concrete. The summer time table of the Lufthansa recently published provides for about eighty lines of service, compared with some fifty last year. The new building will meet the 1927 requirements.

Post-War Government Departments.

IN introducing the Budget in the House of Commons on Monday, April 11th, the Chancellor of the Exchequer, Mr. Winston Churchill, made reference to the future of the post-war Government Departments, which include the Ministry of Labour, the Ministry of Pensions, the Ministry of Transport, the Department of Mines, and the Overseas Trade Department. The Prime Minister had, he said, authorised him to state that during the present financial year changes would be made in the constitution of the three last-named departments. Arrangements will be made to abolish the Ministry of Transport as a separate department, but the full activity of the Roads Department will be maintained. It has also been decided that arrangements shall be made to distribute the function of the Department of Mines, and to terminate the separate existence of the Overseas Trade Department. These changes, Mr. Churchill said, will require legislation, and their consequences will require careful adjustment. A full opportunity for Parliament to consider them will be afforded. Tribute was paid by the Chancellor to the excellent service which has been rendered by the principals of the three departments which will be affected.

Wages in the Engineering Trades.

AT a conference held in London on Tuesday, April 12th, the engineering trade unions presented to the employers an application for a revision of the wage rates in the industry. As was expected, no specific claim was put forward by the unions, but they invited the employers to make an offer. It was decided to adjourn the conference for five weeks in order to allow the Engineering Employers' Federation to consult its district associations. A new conference is called for May 19th. Mr. J. T. Brownlie, the President of the Amalgamated Engineering Union, presented the case for the unions, and reviewed the negotiations of last year. He made reference to valuable orders received by engineering and shipbuilding firms since the beginning of this year, and the renewed activity in shops and shipyards, which indicated a definite revival of trade. That improvement was borne out by the unemployment records of his union, in which a percentage of 12·8 unemployed members in December last had fallen to 8·06 per cent. at the end of March. He recalled the difference in cost of living, which meant that if the same standard of life was to be maintained a man who earned £2 5s. in 1914 should receive £3 19s. to-day. With regard to the emigration of metal workers, it was pointed out that in the years 1922 to 1926 inclusive there had been a loss to this country of no less than 43,000 skilled mechanics. Also, unless there was an inducement of higher wages, there would inevitably be difficulty in maintaining an adequate supply of apprentices. In conclusion, Mr. Brownlie stated that if the employers would make a concession it would go a long way to secure peace and harmony in the industry. Sir Allan Smith, replying for the Employers' Federation, complimented Mr. Brownlie on his statement of the case and the high plane of argument maintained. The employers, he said, would give earnest consideration to the representations which had been made, and would refer the matter to the district associations.

The Modern Steam Engine and Internal Combustion Motors.

By MAURICE DEMOULIN.

No. I.

THE two first principles of thermodynamics can be stated as follows :—

(1) If, by means of a given mechanism, it is possible to unite two phenomena, each of which is the repercussion of the other, it will never be possible, whatever device be employed, to obtain alternately a definite result from one or other of these phenomena, and, in addition, a new phenomenon which would represent a benefit.

(2) In every heat engine the production of energy is invariably accompanied by the loss of calories in one body and by an increase of temperature in the other in which the temperature is lower.

Now, heat and molecular movements are, after all, the same phenomena compared by different standards.

Since the energy of movement cannot become negative, and the development of energy being for every degree Centigrade $^1/_{273}$ of the molecular energy from the basis of melting ice, immobility of the molecules occurs at — 273 deg. Cent., which constitutes the absolute zero.

For all gaseous masses, $p\,v$, the product of the volume by the pressure is proportional to the absolute temperature T_1, from which is deduced the known equation of a perfect gas : $p\,v = k\,T_1$.

If T and t in degrees Centigrade are respectively the initial and final temperature of the fluid, then the theoretical efficiency of all heat engines is given by the relation $\frac{T - t}{273 + T}$, a maximum which could only be obtained with a perfect gas in an ideal and absolutely adiabatic engine, and no mechanical system is able to increase it.

These elementary and classical definitions have the advantage of fixing the ideas and of limiting scientifically the results that can be obtained, encircling, as I may say, all the phenomena. They show that efficiency can only be increased by raising the initial or reducing the final or exhaust temperature of the working fluid. It is certainly more rational, theoretically, to produce combustion inside a cylinder itself—that is, to elevate the temperature and pressure corresponding to the kinetic energy to be made use of—than to resort to an intermediate fluid and to boilers. But such a result has only been industrially attained recently, and has probably, owing to practical considerations, its limitation.

As regards steam, the temperature T to be considered is that of saturation, the increase of calories through superheating has another purpose—thermic, not thermodynamic. From this fact results a difficulty which the engineer has had to face since the invention of the steam engine, namely, that the increase of initial temperature is a function of the pressure and that, for example, to pass from a temperature of 250 deg. Fah. in round numbers to a temperature of 470 deg. Fah., the pressure of steam has to increase from 15 lb. to 500 lb. This inconvenience is, as we shall see, compensated by some advantages, and its importance lessens with the progress of metallurgy, of boilermaking, and with the introduction of new types of boilers.

Steam enjoys the advantage of a low exhaust temperature, thanks to the use of the condenser. In practice that temperature was brought, at an early date, near to the limit obtained to-day with air and water pumps of the most improved design.

The internal combustion engine, on the contrary, has enabled engineers to raise considerably the initial temperature T—with initial pressures higher than those recorded in preceding paragraphs for steam at 470 deg.; but this pressure, of course, prevails only inside the cylinders—on the other hand, the exhaust temperature has been equally raised. Nevertheless, the difference $T - t$ is much higher than in the case of steam, even at very high pressures, and the theoretical efficiency is improved in the same proportion. Good Diesel motors burn in service and on commercial load an average of 190 grammes of oil per effective H.P. When the boilers of a good steam engine are fired with oil fuel, the rate of consumption is about 560 grammes per I.H.P., or 600 grammes per effective H.P. If we consider exclusively the weight of oil consumed, the motor is more than twice as economical as the steam engine. But it is not only the weight of fuel that must be considered, but the corresponding price. Now, the price of fuel oil for steam engines is a good deal lower than that of Diesel oil, so that the real advantage, considering only the fuel consumption, is notably less than the preceding comparison would lead us to believe. It is a question to which we shall return later.

The efficiency of the internal combustion motor would, in practice, be higher, if it was not necessary to cool by water circulation the cylinders, their covers and the pistons, to avoid seizing and to make good internal lubrication possible. Furthermore, the final temperature t is still too high, and the exhaust gases contain a relatively high number of calories—not to speak of those in the cooling water. This question is the subject of the pre-occupation and researches of some builders and inventors—Still, Burmeister and Wain, &c.—who employ these lost calories to heat one or several auxiliary boilers, the steam thus generated being used for the up-stroke of the main cylinders or for auxiliary work. It is an ingenious idea capable of giving good results, but certainly does not make for simplicity.

The Diesel motor derives its present favour for the propulsion of ships from its economy in fuel, and from the suppression of boilers and stokers, and, I dare say, in some measure, from the attraction of novelties and innovations, and the publicity to which they give occasion. It is impossible to deny the moral influence of this publicity. The builders of such engines have shown remarkable inventive power and great activity, and have rendered these motors, in a very few years, practical and reliable. When considering these statements, one cannot but admit that the steam engine has this time, at least at sea, met with a serious competitor, and must undergo some additions and improvements to maintain its position.

The question is no longer strictly confined to technical considerations ; it embraces many private interests, very honourable as being the result of much ingenuity and research, and necessary to the successful development of novelties, but which hinder in some measure the impartial and free judgment of which we should never tire. In such matters one has to be cautious of all ideas fixed *a priori*. Everything ought to be weighted and discussed. It must be remembered that the steam engine is only supported by its own accomplishments.

The evolution of the internal combustion motor has been exceedingly rapid, if compared with that of the steam engine, for many obvious reasons ; but largely because the principal mechanical problems had been solved in steam engineering before its birth. The general disposition of the motor is very similar to that of the steam engine. In other words, the motor has availed itself of the improvements applied to the steam engine and of an experience acquired during a century.

Many different considerations, having no relation whatever to the fuel economy, have to be weighed in the choice of motive power, and they differ according to the kind of service to be performed or the importance of the plants. One would commit a gross error in being wedded too closely or exclusively to fuel economy though its importance must never be lost sight of, especially nowadays. The question is an intricate and complex one.

I have sufficiently insisted on the advantages of internal combustion motors, I believe, to point out impartially the drawbacks they may present for service at sea—by far their most notable application. They need engineers particularly careful and well trained ; their weight and price of first instalment are higher than for a steam engine of the same power, consequently they involve higher sinking funds ; their weight per H.P. has prevented their adoption up to the present time for very fast ships ; their general mechanism, ingenious as it may be, is complicated, at least for four-stroke motors, the most economical in fuel. It is not possible to develop in one cylinder more power than a given figure, without excessive heating ; hence it is necessary to increase the number of cylinders with their corresponding gears, in proportion to the power to be developed. Beyond a certain amount of power, the complication of the whole installation becomes considerable and greater than would be the case with a steam engine, even including the boilers. When turbines are used, this fact is particularly obvious, no other engine being able to compete with them in the respect of power developed per unit of weight, at least when water-tube boilers are used.

It is only fair to add that the recent introduction of successful double-acting motors has improved the position, and that a few large passenger ships, driven by 20,000 H.P. motors, have been built lately. Double-acting is a very important step in Diesel motor design, and it was expected by specialists to become practical at an early date. It has shown that the fear of overheating of the cylinders and rods was exaggerated, but, of course, several precautions have to be taken, especially to avoid the disastrous effects of cylinder dilatation.

Ultimate practice will show if these large power motors are, all expenses and considerations being accounted for, a real practical success, and should be imitated. Experience only, and after several years of service, will be able to determine whether we are here on solid ground, or if the maximum practical power has been exceeded. Nevertheless, and whatever may happen, the steam engine will not be relegated to the second place, and no actual fact leads us to believe that it will be replaced with advantage at sea, for large power and even for moderate power, and long or hard service.

Notwithstanding the improvements of design and construction and the adoption of double-acting motors, there will remain weak points which the ingenuity of inventors will not be able to overcome, most of them being inherent in the principle of Diesel motors —lower mechanical efficiency ; compression and initial effective pressure very high, especially if compared with compound and triple-expansion engines or with the mean effective pressure, involving the use of very thick cylinders and reinforced covers or special cast iron or even cast steel ; connecting-rods and shafts calculated for this maximum pressure, and the corresponding stress, however short its duration for each stroke, are consequently very heavy ; necessity of employing fly-wheels weighing many tons for high power motors, by reason of the coefficient of irregularity ; necessity of first-class workmanship, almost of precision, and of minute and very careful maintenance ; and last, the exclusive use of liquid fuel of a given quality and therefore expensive, and which has to be imported in Western Europe.[1] Besides, it seems likely that the price of the appropriate oils will increase with the development of motors, perhaps later to a high rate. On the other hand, petroleum oils spring by themselves, and therefore are not liable to suffer periods of scarcity as the result of strikes, as coal is. But the steam engine may enjoy the same advantage, the firing of boilers by fuel oil being always a possibility. My intention is not to criticise with partiality a very interesting type of motor, able to render great services when judiciously adopted, but, on the contrary, not to be exclusive and to present all arguments concerning the question.

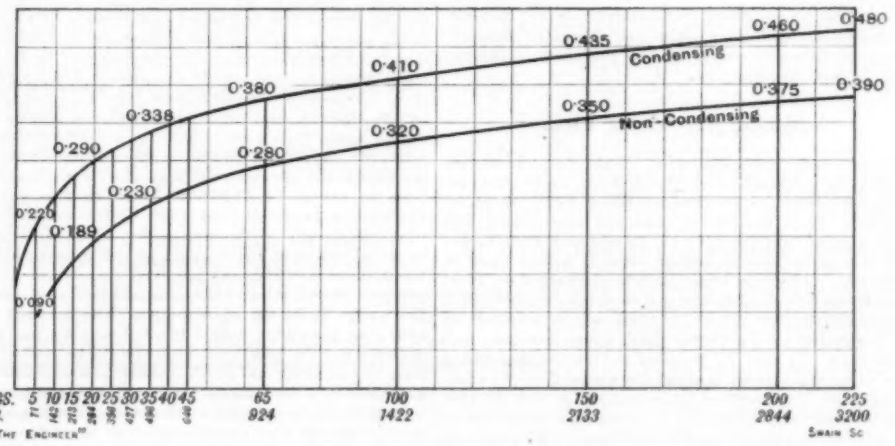


FIG. 1—EFFICIENCY CURVES

As regards engineering particularly—I choose this example as furnishing by far the largest application of motors measured in horse-power—there cannot be one and sole solution. The choice for the owner or maker depends on many circumstances—kind of service to be performed ; speed ; necessity of easy and frequent manœuvring ; countries or harbours of call, &c.

Summing up, the development of internal combustion motors must not, at any rate, deflect attention from the steam engine, which is at once so simple, of such plain construction, so reliable and durable, and easy to manœuvre, nor must we disregard the remarkable improvements which it has undergone in recent years, and can yet undergo. Moreover, on land, for the great electric stations, steam plants are almost universally resorted to, and in very economical conditions. It is likely that the appearance of the Diesel motor has not been without some influence on the progress and development of the steam engine ; so also have been the continually increasing cost of fuel and the extension of power actually needed.

Yet, if we refer to the results of trials carried out with the motors—two stroke, 3000 H.P.—for a large commercial ship which have been reproduced in several technical papers of late, it is curious to note

[1] Great Britain, France, Belgium, and Germany can put out yearly about 600 million tons of coal, whilst all petroleum oils have to be imported. Now, of course, ships calling at different harbours belonging, like those of North America, to countries owning oilfields can fill up their reservoirs or tanks or complete their stocks.

that the final thermal efficiency is 29·6 per cent. Now, if we consult the curves of efficiency given in Fig. 1, we note that this figure is exactly the same that would correspond theoretically to the efficiency of an ideal steam engine working adiabatically at the pressure of 285 lb. with a good vacuum. Of course, the real engine would be subject to losses through the cycle reducing this efficiency, but it shows that steam engine and motors are not so widely different as some people are inclined to think, and that the problem consist mainly in taking the necessary steps to lessen these losses to the utmost. These losses have been analysed and are well known; many have been considerably reduced, thanks to boilers having an efficiency of 94 per cent., and the introduction of several improvements, of which I shall speak later. Be it sufficient to know that some recent marine engines, having good boilers and poppet valve gears, have shown a consumption of steam of only 4·30 kilos., or 9·43 lb., per horse-power, and even 8 lb. with turbines.

The improvements stated here are susceptible of being applied more or less completely to the different uses of steam—stationary plants, steamers, locomotives—according to the conditions of the service or the possibilities and circumstances. To quote one example only, the question of weight has not to be considered in the case of fixed plants, but is of vital importance in the two other applications. The system adopted ought therefore to vary according to the conditions to be performed—within certain limits, of course.

The steam engine presents many advantages. Thus, on board ship it is noted for its almost complete flexibility, its readiness to respond to all calls made upon it, its robustness which enables it to work in conditions of wear and tear that the internal combustion motor could not tolerate, its ability to run at the lowest speeds, and to reverse in the minimum possible time. It works smoothly and noiselessly, it complies with the hardest services, from the trawler or tug to the most powerful passenger steamers, as well as to the Dreadnoughts or the fastest cruisers. Slow-running and strongly built, with a long stroke, as is classical with experienced British yards, for cargo boats or mixed ships, its life is very long—so to say, unlimited—and it can be kept in good repair at a relatively small cost. I do not very clearly visualise the Diesel motor applied to tramp ships or to the large Newfoundland trawlers steaming and pounding for months on the Banks, far from any point of call or repairing shops.

The steam engine offers also a very low weight per H.P. when designed on purpose, with a high number of revolutions per minute, and with the boilers of the water-tube type pushed with forced draught. It allows the use of turbines, entirely balanced, keeping a part of the preceding advantages and offering new ones, especially if we consider lightness and compactness and the reduction of wear and tear, notwithstanding an adequate rate of expansion.

The material used, cast iron or steel, not being subjected to very high temperatures or excessive stresses, may be of ordinary quality; the shafts and crank shafts, particularly, are made of mild steel, and never, at least for merchant ships, of special metal of high tensile strength, this giving facilities for repairs or for fitting new shafts in case of damage or breakdowns in far-off harbours or in places not having the necessary equipments.

With the steam engine, especially when triple-expansion, the initial pressures, inside the cylinders, are not raised so suddenly or violently as in the oil engine; the portion of stroke at approximately constant pressure being generally 40 or 45 per cent., the mean effective pressures are seldom less than the half the initial pressure. Hence, the engine operates with great smoothness, without any jerks. Consequently, the shafts, rods, connecting-rods, &c., are a good deal less heavy and massive than in oil engines, and fly-wheels are dispensed with.

The steam engine allows of the use of any kind of fuel. Besides, it is able to develop the greatest powers without exceptional complication; the introduction of turbines has much contributed to this result. No other type of motor can compete with steam in this respect. The turbines of some liners develop 70,000 H.P., and on board some fast destroyers or cruisers the makers have been able, notwithstanding the small displacement, to arrange turbines developing 160,000 H.P. and more, but, of course, using oil fuel for the firing of the boilers. Some of the more important electric stations have a yet much larger output of power, as, for example, Gennevilliers, near Paris, one of the largest, if not the largest, existing, with 300,000 kilowatts and increasing.

But the boiler is the steam engine's weak point, as is well known, its principal drawback, not in what concerns economy of fuel, some boilers having an efficiency of nearly 95 per cent., but by reason of the inconveniences it presents—room occupied, bulk, wear and tear, corrosion, &c. If, on board ships, it is of the cylindrical type when it has to be replaced, its removal may render necessary important demolitions and work. But it is fair to remark that water-tube boilers and oil fuel have decreased these inconveniences to a minimum.

On the other hand, acetylene or electric welding enables important repairs to boilers to be undertaken without landing them. This kind of welding, when carried out by competent and conscientious specialists, gives every satisfaction and may be considered as a remarkable step, presenting facilities that could not have been suspected twenty years ago.

Since the use of solid-drawn steel has spread for the manufacture of main steam pipes, the risks and difficulties of installation have almost disappeared for the largest plants and highest pressures. They never burst wide open like copper pipes, and are quite reliable. All prejudice against them has disappeared, experience having shown that they are not subject to rust and corrosion or pitting inside, their inner surfaces being rapidly coated with a greasy mixture. They are perfectly safe if they are inspected and cleaned outside once a year. Some makers prefer a number of equivalent pipes of small diameter to one large one. The safety of the whole installation is then quite complete.

In short, the steam engine of to-day in its principal applications and for great powers or long sea voyages and hard service, at least, constitutes as a whole a system offering the minimum number of drawbacks. It is always reliable, does not necessitate minute erecting nor special and costly materials, and offers all guarantees of security and reliance if well designed and built.

When designing a new plant, one has, finally, to consider carefully where the advantage lies in the case under consideration—practical advantages and lower cost of the steam engine, or lower consumption of fuel of the internal combustion motor.

(To be continued.)

A Determination of the Efficiency of an Exhaust Gas Boiler.

By Professor G. COOK, D.Sc., M.I. Mech. E.

IN the average internal combustion engine the amount of heat which is discharged to the exhaust—calculated from the temperature of the air—is roughly equal to that which is converted into mechanical work by the engine. The problem of the recovery of this heat in some useful form has received considerable attention, the most notable achievement being that of the Still engine. In this engine, as is well known, steam is generated from the heat discharged both to the jackets and exhaust, and is employed to increase the power of the engine without any additional expenditure of fuel. There are many industrial processes where a supply of low-grade heat

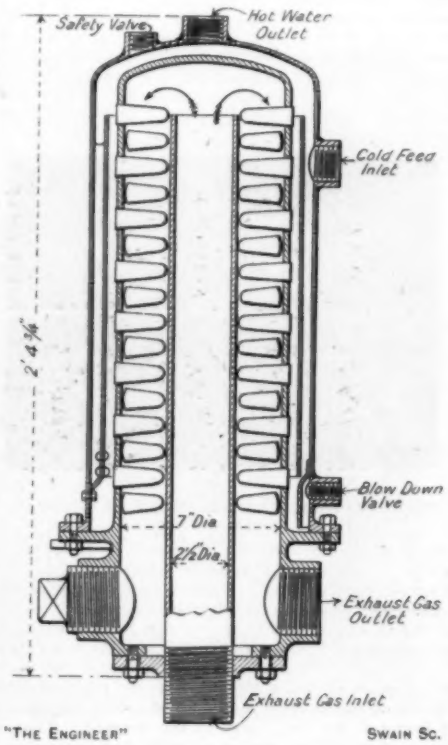


FIG. 1—SECTION OF CLARKSON EXHAUST GAS BOILER

is required, either in the form of low-pressure steam or hot water, and where the power for such processes is supplied by internal combustion engines the exhaust furnishes a means of obtaining at any rate a portion of this heat without any additional consumption of fuel.

The present article gives the results of a number of tests carried out on a small waste gas boiler constructed by the Clarkson Thimble Tube Boiler Company, Ltd., and fitted to an 18 B.H.P. Crossley gas engine installed in the engineering laboratory at King's College, London. The general features of the design of the Clarkson boiler have already been described in the Olympia Exhibition Supplement published in THE ENGINEER of November 20th, 1925. The type of boiler used in the present tests is shown in Fig. 1, and in Fig. 2 a general view of the installation is given. The gases from the engine pass through the central pipe to the top of the boiler, and then descend over the thimble-shaped tubes, being finally discharged to the exhaust pipe at the base. The apparatus is designed for the purpose of heating water only, no steam space being provided. The total heating surface area is 11 square feet.

The performance of a waste heat boiler is frequently expressed as the amount of water evaporated—or the heat transmitted through the heating surface—per B.H.P. developed by the engine. The simplicity of the measurements involved in this determination is perhaps a sufficient justification for the practice. It is, however, open to the objection that the performance of the boiler is dependent on the overall efficiency of the engine. The same boiler would give a better result when used with a gas engine than when used with a high-compression oil engine. It would appear desirable, in estimating the true efficiency of the boiler, to treat it as a self-contained unit, and determine its performance on the basis of the actual heat received by it from the engine. This necessarily involves a knowledge both of the weight of the exhaust gases and of the heat content which is available, and in this connection several difficulties are encountered in deciding what should be considered as the available heat.

In a coal-fired boiler that available heat is taken to be that given out by the combustion of the fuel in oxygen, the products of combustion being cooled to the original temperature of the fuel. The latent heat

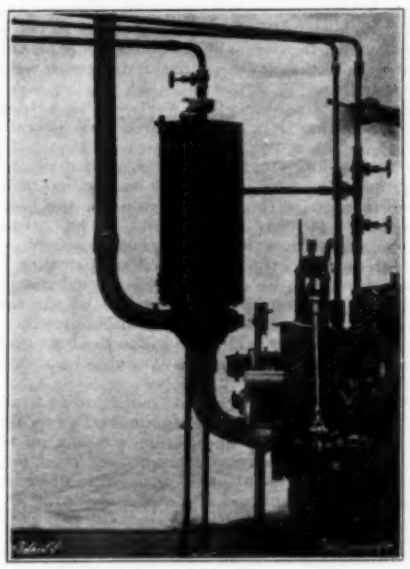


FIG. 2—ARRANGEMENT OF BOILER AND ENGINE

of the vapour of combustion may or may not be taken into account in this estimate of the available heat. For an average steam coal the latent heat of the vapour of combustion amounts to a little over 2 per cent. of the gross heat of the fuel, and this will therefore represent the difference between the efficiency of the boiler as calculated from the gross as against the net calorific value.

The exhaust gas from a gas engine will usually contain about 10 per cent. by weight of water vapour, and its latent heat at the partial pressure corresponding to this amount is as much as 25 per cent. of the whole heat in the exhaust gas, calculated from atmospheric temperature. It may be taken for granted that with ordinary materials of construction condensation must not be allowed, on account of the corrosion which would result. It should therefore not be taken into account in determining the available heat. The exclusion of so large a proportion of the total heat does, however, introduce an appearance of artificiality into an estimate of the thermal efficiency.

Assuming that the question of latent heat is satisfactorily dealt with in this way, a further difficulty is introduced owing to the unreliability of temperature measurements of the exhaust gas as it leaves the engine. The specific heat of the exhaust gas is known within sufficiently close limits, but the determination of the temperature of a rapidly moving hot gas—especially when the motion is intermittent—is a matter of some difficulty. The temperature of the gas leaving the boiler, being as a rule less than 300 deg. Fah., is much more readily obtained, and it is probably best to estimate the available heat by adding the heat given to the water to the residual heat discharged, and neglect the radiation, which in a properly lagged boiler will in any case be small.

A further point to be settled before the available heat can be determined is the temperature base from which it is to be calculated. In a coal-fired boiler no difficulty in this respect is encountered, as in the determination of the calorific value of the fuel the products of combustion are cooled to the original

temperature of the fuel. This is equivalent to treating the atmospheric temperature as the base. In a boiler using economisers and no air preheaters—regarding these as part of a boiler installation—it would be more appropriate, on a strict view of the meaning of the term available heat, to regard the temperature of the feed water entering the economiser as the true base. The difference, however, in any practical case would be quite negligible. Where air preheaters are used in place of economisers the air temperature would be the strictly correct base.

This question, entirely unimportant in the coal-fired boiler, becomes one of considerable importance in the waste heat boiler, as the whole heat supplied is of a rather low grade. The ideal heat recovery plant would be one which would extract the maximum amount of heat from the gases, or, in other words, cool them to the lowest possible temperature, disregarding, in this connection, any question of condensation, which has been dealt with above. The lowest temperature to which it would theoretically be possible to cool the gases would be the feed water temperature, and it appears to the writer that that is the proper base to take in calculating the available heat. The importance of this point will be seen when we examine two cases, first where the feed water is supplied at the temperature of the mains, say, 45 deg. Fah., and second, where it is received from the engine jackets at a temperature of, say, 140 deg. Fah. In the second case the average temperature difference between the gas and water will be less than in the first, and therefore less heat will be transmitted through the heating surface. The maximum amount of heat that could possibly be transmitted with a perfect heating surface is also reduced, as the gases could not be cooled below 140 deg. Fah. The difference in the available heat in the two cases is about 10 per cent., and the efficiency figure of the boiler would be affected to very nearly that extent if the difference were not recognised.

In the tests recorded here the available heat in the exhaust gas has therefore been determined as follows:—The weight of the exhaust gas was obtained from the weight of air and fuel gas used, both of which were metered. The moisture content was known from the determination of the calorific value of the fuel gas, and the specific heat of the exhaust gas was calculated on the assumption that the vapour remained uncondensed down to the feed water temperature. The sensible heat in the gases leaving the exhaust boiler was then determined as the product of the weight, specific heat, and temperature difference between gas and feed water. This, added to the heat given to the water, was taken as the available heat supplied to the boiler.

A series of tests was carried out in order to obtain the efficiency with varying amounts of water flowing through the heater. The engine, running on town's gas, was maintained at constant power, speed, mixture strength, &c., for all the tests, the observations common to them being as follows:—

B.H.P. of engine		18·3
Speed		262 r.p.m.
Calorific value of gas :	Gross	503 B.Th.U. per cu. ft. at N.T.P.
	Net ..	457 " " " "
Weight of exhaust gas		3·23 lb. per minute
Temperature of exhaust gas leaving engine		1050 deg. Fah.

The results of the tests in which the feed water was supplied from the mains—temperature 45 deg. Fah.—are shown by the curves in Fig. 3. The efficiency, as would be expected, increases as the amount of water passing through the heater increases, but the rise of temperature of the water is necessarily reduced. A curious feature of the curves is the rapidity with which the final temperature of the exhaust gas falls for a comparatively small increase in the flow of water over a portion of the range. When the water is raised to the boiling point and steam is just formed the final gas temperature was found by a separate test to be 310 deg. Fah. As the flow is increased the temperature falls slowly and quite regularly until a temperature of about 250 deg. Fah. is reached, when it becomes extremely sensitive to the slightest change in the amount of water, falling to 160 deg. Fah. for an increase of only 1 lb. per minute in the flow. When the flow is further increased the temperature gradually approaches 138 deg. Fah., which is approximately that of the dew point of the gas. Under the latter conditions considerable condensation was manifest, and the writer is inclined to regard the sudden change in slope of the gas temperature curve at about 250 deg. Fah. as the point at which some local condensation is beginning to take place. He has, however, no other evidence in support of this view; there does not appear to be any discontinuity in the rise of temperature of the water, as might be expected if certain portions of the heating surface were receiving the latent heat of condensation. A satisfactory explanation has in fact not yet appeared.

The efficiency curve, being calculated from the residual heat in the gas, would possess the same inflexion. The portion shown dotted, in view of the possibility of condensation over this region, is of little value. The useful range appears to be between 79 and 82 per cent.

A test was also run under the same conditions as those tabulated above, in which the jacket water of the engine supplied the feed to the exhaust boiler. The quantity of water heated under these conditions was 9·12 lb. per minute, from a temperature of 132 deg. Fah. to 208 deg. Fah. The rise of temperature in the jackets was 92 deg. Fah., and in the heater 76 deg. Fah., while the efficiency of the boiler was 83 per cent.

A question of some importance in connection with the use of waste heat boilers is their effect upon the efficiency of the engine. There is some divergence of opinion on this point. On the one hand, the view is held that the introduction of the boiler in the exhaust pipe must increase the back pressure and adversely affect the efficiency; on the other hand, cases have been recorded where a definite improvement in the efficiency has resulted from the introduction of the boiler. To investigate this point two tests were carried out, first with the boiler in use, and then with the boiler removed and a plain exhaust pipe inserted in its place. The two tests were carried out on the same day, under identical conditions of

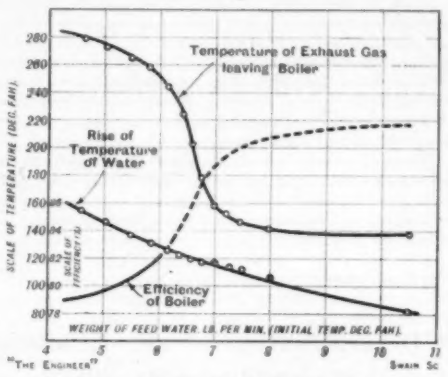
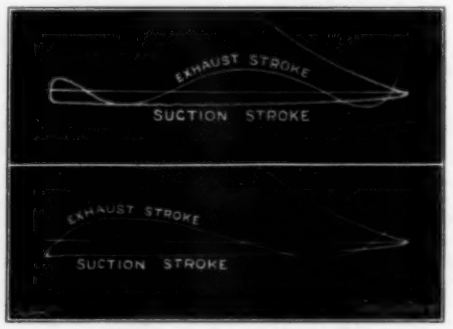

Temperature of Exhaust Gas leaving Boiler
Rise of Temperature of Water
Efficiency of Boiler
SCALE OF TEMPERATURE (DEG. FAH.)
SCALE OF EFFICIENCY %
WEIGHT OF FEED WATER, LB. PER MIN. (INITIAL TEMP. DEG. FAH.)
"The Engineer"
Swain Sc

FIG. 3—CURVES OF TEST RESULTS

load, speed, &c. It was found that there was no measurable difference in the consumption of gas, but that the air consumption was greater by some 1½ per cent. when the boiler was in use than when a plain exhaust pipe was substituted. This showed at once that if any back pressure was caused it did not continue till the end of the exhaust stroke—the really vital point. On the contrary, it indicated the existence of a negative pressure over that portion of the cycle where the opening of the admission valve overlaps that of the exhaust. Light spring diagrams show this effect in a very striking manner. The upper diagram Fig. 4 is taken with the plain exhaust pipe. The fluctuations in the pressure during the exhaust stroke are the result of vibrations in the column of gases in the exhaust pipe, and the frequency of these vibrations is such that the pressure happens to be positive at the end of the stroke, at the time when both valves are open, thus retarding the admission of the new charge. The lower diagram Fig. 5 shows the conditions with the boiler in use. The effect of the



FIGS. 4 AND 5—LIGHT-SPRING INDICATOR DIAGRAMS

boiler is to increase the capacity of the exhaust system, resulting in a lower frequency of the vibrations, so that in this particular case the pressure is negative at the end of the exhaust stroke. This condition is specially favourable for good scavenging. In a gas engine, where the fuel is already mixed with the incoming air, such a condition might not necessarily result in better efficiency, as the improved conditions of combustion might be offset by the passage of some of the fuel direct to the exhaust. That, in the opinion of the writer, is what has happened in the present case—an increase in air consumption without any appreciable effect on the efficiency. It is readily conceivable, however, that in an oil engine with fuel injection a condition such as this would entail a distinctly improved efficiency, and in those cases where such an improvement has actually been observed it is probable that the cause will be found to be similar. The writer is not prepared to say that such improvement must necessarily follow the installation of the boiler. The same effect might very well be produced either by a lengthening or a shortening of the exhaust pipe; there can be no doubt that small changes in the exhaust system have a much greater effect upon the performance of the engine than is generally recognised. It can, however, be definitely stated that there is no evidence of any sustained back pressure being caused by the boiler.

A New Switchgear Works.

The increasing demand for switchgear of various types and of other electrical apparatus has made it necessary for the Oerlikon Company to construct a new building in which the various switchgear shops, previously distributed in different parts of the factory, are now concentrated. Work was commenced on the new building in 1925 and the staff was transferred to it early in the spring of last year.

In order to permit of the manufacture of all kinds of switchgear, ranging from the largest circuit breakers down to such things as relays, under the most favourable conditions, the new works were designed to form a combined storied building and a shed structure. Situated on the border of the old factory site and facing the street, the new building is linked up with the other parts of the Oerlikon works with a wide factory roadway, and it has its own street entrance and gatekeeper's house. A plan and elevation of the building are shown in Figs. 1 and 2 respectively, whilst Fig. 3 and Figs. 4 to 7 on page 414 give various views of the interior of the works.

The inner part of the building, which is of U shape formation, is occupied by the erection shed, which extends up to the second floor, the height available under the crane for the erection of the switchgear being 23ft. The width of the building is 164ft., whilst the wings, which have been designed so that they can be extended, have a length of 115ft. Excluding the basement, the total height of the building is 65ft. The basement, ground floor, and first and second floors are used as workshops, whilst the top floor serves for offices. The soil on which the building is erected is of irregular formation. It consists of gravel and sand deposit, and as the water can rise above the level of the basement floor even during periods of

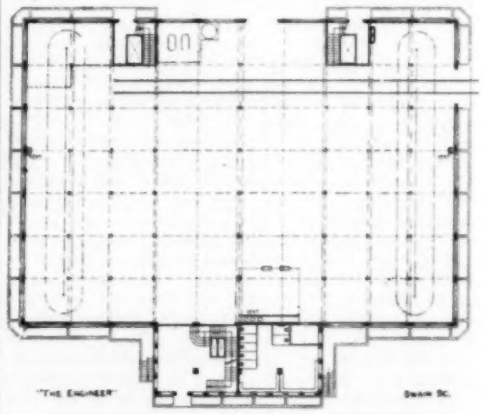


FIG. 1—PLAN OF SWITCHGEAR WORKS

average rainfall, it was necessary to take special precautions in order to keep the rooms in the basement perfectly dry.

On account of the presence of sand and its liability to be washed away, the possibility of lowering the level of the ground water was out of the question. The difficulty was, however, overcome by erecting the building on a continuous base of reinforced concrete, which, together with the outer walls of the lateral light shafts, is made water-tight by means of a special preparation, and in order to ensure effective stiffening of the foundations the whole basement, including the supporting walls, the columns, and the light shafts, is composed of uniform reinforced concrete construction, some 172 tons of iron and 56,500 cubic feet of concrete being used for the purpose. The floor of the basement is about 2ft. 3in. above the surface of the concrete foundations and the space in between is utilised for accommodating the drain pipes and the ducts for heating and ventilation. As the ceiling of the basement has no supporting beams, but is carried by columns with very wide conical capitals, visibility and space are materially increased. From the top of the basement upwards the main body of the building is of iron construction, whilst the walls consist of masonry work, in which the metallic structure is encased. At the level of the second and third floors the two wings are linked up together by rooms built over the erection shed, thus giving an additional floor space of 6450 square feet without affecting the shed lighting. For the structural work of the building about 600 tons of iron were used. In order to avoid encroaching on the space of the shops and offices, and to give easier supervision, the main staircases have been placed in a separate tower which reaches above the top storey and is situated on the side of the building facing the street, whilst in the centre there are two passenger lifts, the lavatories, and a room for fans and hot water boilers. There are also other staircases and a goods lift at the end of each wing.

The intermediate floors of the building are composed of an iron framework with cemented slabs between, and the whole is covered with a layer of concrete, a form of design which makes it easy to carry out subsequent structural alterations or to cut openings in the floor for pipes, &c. The floor covering in

the basement is asphalt. In the workshops wood blocks set in asphalt are used, in the lavatories tiles, and in the offices linoleum. An insulating air space is provided in the roof, which is made waterproof by means of a special preparation. A hot water central heating system with a circulating pump is used for heating the building, whilst ventilation of the basement rooms is provided by sets of fans in each wing. The fans also supply fresh air to the different shops through ducts run throughout the different floors.

At present the switchgear works provide employment for about 500 workpeople, who carry out their duties in the basement, on the ground floor, and on the first and second floors, the top floor over the oil-blacking processes, and a shop for assembling metallic fittings on porcelain insulators. In spite of their low level, all the basement rooms have plenty of daylight, whilst good heating is ensured by a combined system of warm air and warm water heating. Gas and hot and cold water and electric light and power mains are laid throughout the basement.

The ground floor, which has an area of 18,850 square feet, accommodates in the right-hand wing the milling, drilling, stamping and pressing shops, the machines being driven in groups by electric motors, and when installing the plant arrangements were made for the installation at a later date of a belt conveyor for serving the machines. The left-

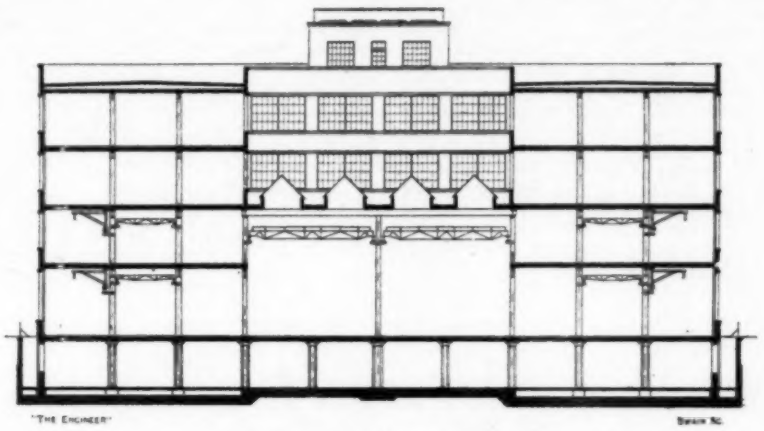


FIG. 2—SECTIONAL ELEVATION OF SWITCHGEAR WORKS

erection shed, which has an area of about 15,600 square feet, being used for offices, including all the drawing-offices for apparatus and switchboards. A galvanising room in the basement contains all the different metal baths for galvanising and for plating with copper, nickel and silver. There is also a large conveyor bath for the accelerated metal plating of articles produced in great quantities, and a tilting zinc bath for intensive and rapid plating with zinc, while a large zinc bath is provided for large and cumbersome parts. There is also an installation for removing the grease from metal parts by the galvanic process, and a plant for removing the grease from parts by subjecting them to the action of lime water. The hand wing contains the switchboard and erection shop for oil circuit breakers, for which considerable headroom is often required. The height of the ground floor shops in the wings is 17ft. 3in. There is also, as already stated, a central erection shed, for the erection of large switchgear equipments, the height available between the floor and the level of the crane runway being 24ft. 10in. This shed has two bays, each of which is served at the present time by a 5-ton electric crane operated from the floor level. A standard gauge track, constructed in accordance with the Oerlikon Company's design, is laid in the erection shop, so as to permit of the loading of manufactured goods on to railway trucks and of the unshop for traction apparatus. The two shops are connected by a gallery on the west side of the erection shed and the gallery is provided with two loading platforms which can be served by the shed cranes. The second floor is used entirely for the manufacture of small parts and apparatus and relays, and the test room for the apparatus is also situated on the same floor. In view of the very wide range of the gear that is manufactured, the test room is laid out on very comprehensive lines. The various supplies of current derived from the generating sets are brought on to the panel of each test bench, and by inserting a plug in a socket it is possible to connect up any of the sources of current to the working terminals through regulating resistances and a transformer or induction regulator. In addition to the regulating gear, each test bench is fitted with all the instruments that are required for testing purposes, provision being made for the measuring of resistances, for testing current transformers and for insulation tests. Mains are also run from each source of current to the test room in the oil circuit breaker shop, so as to permit of the testing of gear which cannot be transported to the apparatus test room on account of its size. In all the workshops, hot and cold water, gas, compressed air, electric light and power are available, whilst on the ground floor connections can be made with oil mains for the purpose of filling oil circuit breakers. The bui ding has its own hot water heating system.

The materials for manufacturing purposes are supplied to the workshops and the completed articles are removed by two goods lifts, which serve all the floors. The lifts are designed so that they can take the electric trolleys used for the transportation of materials, with the result that there is no need to unload and reload the materials between the workshop and stores. On the top floor all the technical offices are situated. The main entrance to the building is in the tower, which contains two passenger lifts for the use of the staff, whilst at the ends of the wings of the building there are staircases. Although the offices are directly below the roof, they do not get unduly hot in the summer, as they are protected by a heat-insulating space. The workmen's dressing-rooms are situated in the basement, where there are lavatories and lockers, the dressing-rooms being reached by two staircases at the side of the tower.

The advantages derived from the centralising of the different switchgear departments and the better facilities for supervising the manufacture of goods, together with the more favourable lay-out of the shops and offices, have led to a reduction in the cost of production and improvement in the quality of the goods, these considerations being the determining factors when it was decided to incur the heavy expenditure which the new works entailed.

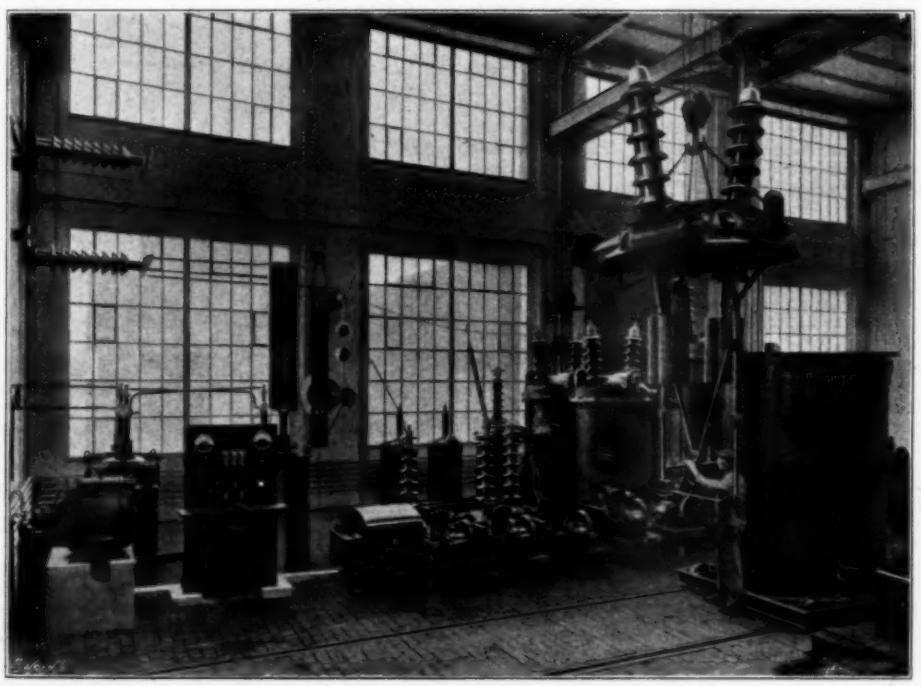


FIG. 3—HIGH-PRESSURE TESTING EQUIPMENT

necessary low-tension direct-current supply is derived from two motor generator sets which are used for the above processes. A buffing and polishing plant is installed in a neighbouring room, which is ventilated on the forced system, the impure air being drawn away by a suction plant.

In the pickling room, which is also situated in the basement, all the parts which come from the foundry, the stamping shop or pressing shop and which almost invariably have to be pickled, are dealt with. As a rule, the pickling is done with nitric acid or with a mixture of nitric or sulphuric acid, and special provisions are made for carrying away the fumes, so that the operators may stand in front of the vats without danger. In the basement there is also a room for the loading of the heavy castings, boilers, &c., in the shed itself. In the oil circuit breaker shop there is a testing installation, by means of which high-pressure gear can be tested up to pressures of 350,000 volts to earth. There is also a heavy current motor generator set, designed for a current of 5000 ampères and a pressure of 5 volts, for testing and calibrating direct-current apparatus. For the calibration of heavy current alternating-current gear and for the purpose of studying the effects of heavy currents on apparatus, use is made of a transformer with a continuous rating of 20,000 ampères and capable of dealing with peak loads of about 60,000 ampères.

The first floor provides accommodation on one side for the turning shop and on the other side the erection

Institution of Naval Architects.

No. II.*

EROSION OF CONDENSER TUBES.

WE continue, below, our account of the discussion of Sir Charles Parsons' paper on "Some Investigations into the Cause of Erosion of the Tubes of Surface Condensers," which was read on the first day of the Annual General Meeting of the Institution of Naval Architects on the 6th inst. The paper itself was printed in our last issue.

Mr. A. Q. Carnegie said that the paper contained a description of a very interesting series of experiments which might throw a great deal of light on the causes of condenser tube troubles, and particularly on the question as to whether those troubles were due to causes purely chemical, purely mechanical, or to a combination of the two. The paper which Sir Charles Parsons read in 1919 gave a complete explanation of the destruction of ships' propellers, and made it clear that the action was purely mechanical; it might possibly be proved that the perforation of condenser tubes was due to a similar cause. The experiments on the "water syren" which led Sir Charles to design the water hammer cone, showed that the addition of a short pipe, only ¾in. long, caused the cavities to collapse against the metal of the rotor, and produce on it severe mechanical erosion. Further increase in the length of the pipe caused the cavities to collapse at a lower level, so that the collapse took place in water and did no harm. All the experiments showed that the conditions under which the cavities collapsed were very critical, and that very small changes would produce markedly different results. A case of cavitation came to his notice recently in a centrifugal pump, in which the cavitation was apparently caused by a multiple flap non-return valve that was fitted in the suction pipe immediately adjacent to the suction inlet branch of the pump. It appeared that the wake formed in the water by the framework of the valve plate caused the water to enter the pump in such a state of disturbance that severe cavitation was set up, and great damage to the inner tips of the pump vanes was caused. The presence of the cavities in the water also appeared to reduce the duty of the pump by over 20 per cent., and it was expected that, when the valve was removed, the cavitation would cease and the duty of

* No. I. appeared April 8th.

the pump would become normal. It was interesting to note that, in Sir Charles Parsons' experiments, the discharge through the condenser tubes was greatly reduced when cavitation occurred. The appearance of the eroded metal of the pump impeller vanes was very similar to that of an eroded ship's propeller. The erosion, which was frequently observable on the leading edge of the last row of moving blades in a steam turbine, was now recognised to be due to cavitation; the conditions present in the neighbourhood of the last row of blades being that the blades were moving in an atmosphere of water vapour of low density, and that when a blade struck a relatively stationary drop of water, a cavitational collapse took place, which made an indentation on the surface of the blade metal. A succession of drops on the same place deepened the indentation until it became a steeply conical hole, with the result that the destructive force of the collapsing cavity was made more and more concentrated and it ultimately pierced the blade and left a distinct rag where the pressure broke through to the other side. The rag was similar to that produced on the back of an armour plate when pierced by a projectile. Experience had shown that turbine blade erosion was more rapid when the blade speed was high and when the turbine was exhausting into a high vacuum. Many condensers were arranged with a syphonic leg on the discharge side, and the partial vacuum would therefore intensify the effect of cavitation in the condenser tubes.

Mr. Kenneth Fraser, of the Yorkshire Copper Works, Leeds, said that, as a result of research investigations in his own works, tube makers had for years directed attention to the bad effect of released air and gas in the cooling water. By the employment of glass tubes, the action had been watched, and then tried on all sorts of non-ferrous tubes; tubes as made, tubes artificially coated, and tubes with various types of natural scale on them. As showing the importance of the matter under discussion, he said that quite 90 per cent. of all condenser tube failures fell under the headings of corrosion and erosion. Was it not likely that the vortices mentioned by the author were filled with air or gas, and were not really vacua? In the second paragraph it was said action was greater at the entry end of the tube. That was a positive statement, but it was not borne out by his experience. In modern design of tube packings there was no sharp square entrance to the tube. He agreed as to turbulence, but he would like to see some effort made to get rid of as much air and gases as possible before passing the cooling water through the tubes. The grid designed by the author would certainly tend to cause a steady flow down the tubes. He suggested that it would be made more effective by having a deeper water entrance box in front of the grid, and a suitably shaped division plate, so that entangled air and gas could rise to the top of the water space, where a vent pipe could be fitted to take away the air and gas. He did not think that the vortices were vacua, but that they must contain air or gas. The action of the pump itself would pull air out of solution, and there would be some free gas or air entangled in the water before entering the water box. He would expect any vacuum formed to be immediately filled with gas, which would readily come out of solution at the regions of reduced pressure.

Mr. W. W. Marriner said that the subject of the reliability of the condenser was of an importance which increased with the increase in steam pressure and temperature. To-day many successful examples had shown that an increase in steam pressure and temperature was the most satisfactory way of obtaining the most out of the fuel, as there was no difficulty in making high-pressure boilers or in utilising the high-pressure steam. An investigation therefore was welcomed into the condenser tube trouble, especially when it was conducted by Sir Charles Parsons. Every engineer at some time or another must have tried some experiments on condenser tubes, and he had been looking up some experiments carried out by Sir Alfred Yarrow on the effect of heat, electrical potential and velocity of flow. Fortunately for those in destroyer practice, the condensers were made single flow with well shaped conical ends, and Sir Charles had explained why, to a large extent, the general troubles with condenser tubes had been escaped. He suggested, however, that, probably, condenser trouble was due to a variety of conditions: —(1) The mechanical effect of vortices, which might prepare the surface for the (2) chemical effect of the gases which were set free from solution when the condensing water was heated. He had tried to counteract that effect by increasing the pressure in the condenser, so that the solubility of the gases was increased by pressure, and thus balanced the loss in solubility due to a rise in temperature. (3) The effect of electric potential which could, without doubt, modify the chemical action, but which was almost dangerous in application on account of the human failing of wanting to connect up the terminals the wrong way about. (4) The purely chemical effect of some waters on certain materials. It might be that the troubles were due to various causes, some of which were accentuated and even marked by other causes, and all had to thank Sir Charles Parsons for showing how erosion could take place and that a surface once roughened was very liable to suffer from other causes.

Mr. W. Hamilton Martin remarked that the tests described by Sir Charles Parsons suggested that the cause of the trouble in condenser tubes might be hydro-dynamical, rather than chemical or electrical. A technical journal some time ago, when writing on condensers, stated: "If any part of a tube is subjected to undue stress, a kind of molecular friction is set up which is followed by excessive corrosion. Thus, if the ferrule were screwed up too tight, the tube would be compressed, and this would be followed by rapid failure. A somewhat similar effect is caused by excessive vibration, this also resulting in molecular friction and consequent corrosion. Vibration in the vicinity of the condenser cannot perhaps be entirely eliminated, although it may be greatly reduced by exercising care in the lay-out; in land practice, the condenser is often mounted on springs, so that the effects of vibration are hardly felt in the condenser." He had heard some time ago of two turbine vessels belonging to one of our large steamship companies. They were identical ships, trading on the same route, so that their operating conditions were practically similar. In the one ship there was no marked trouble at all with the condenser tubes, while the other's gave nothing but trouble. Where, outwardly, conditions seemed to be quite alike, it would be interesting to ascertain whether the vibrations of the one vessel in the region of the condenser or possibly of its tubes, differed from that of the other sufficiently to bring about such molecular friction, accelerating the corrosion. It was more than likely that there would be a marked difference in the vibrations at similar positions in the ships. Alternatively, a test might be made on a vibrating condenser tube. If there were anything in that suggestion, it would be necessary to try and eliminate vibrations in and around condensers, especially in marine installations. The author's comments on this suggestion would be much appreciated.

Mr. J. Austin said that, although experiments which he had carried out confirmed the suggestion of Sir Charles Parsons that one of the probable causes of erosion of condenser tubes was turbulent motion of the water in the water box of the condenser, other theories as to how corrosion and erosion were promoted should not be discarded. From observation and examination of many corroded tubes, it appeared to him that the type of erosion now being discussed was promoted from local corrosion. The general appearance of a badly eroded tube showed deep cavities around which large areas had been washed away. It was possible that, once local corrosion was commenced, the sharp edges of the cavity became corroded and at the same time an eddy or turbulence was caused in the water which might affect the tube in a vicinity remote from the effects of the vortex at the inlet end. It seemed hardly conceivable that erosion would commence in the smooth polished bore of a tube, considering that the flow of water was steady and parallel to the walls of the tube. The trouble had undoubtedly become worse since the cooling surface of condensers had been cut down and the water velocity increased, and also since the change from reciprocating engines with low vacuum and high temperature condensers, to turbine engines, with high vacuum and low-temperature condensers. The protective scale found in the tubes of the reciprocating engine condenser was non-existent in the tubes of the turbine condenser. Assuming the causes of erosion and corrosion were as he had mentioned, it was surely not beyond the skill of the engineer and the chemist to find a remedy. The most satisfactory means of arriving at a practical solution to cover all possible causes of corrosion would be to deal with the problem by the following methods, which included that suggested by Sir Charles Parsons:—(*a*) By a better design of water end with grids or other means to prevent vortices forming; (*b*) by the discovery and use of tubes which were impervious to corrosion or erosion; (*c*) by the utilisation of Admiralty mixture tubes coated on the interior with tin, bituminous solution or corrosion resistant scale; (*d*) by fixing a limit to the water velocity; (*e*) by ensuring that the flow of water was even throughout all the tubes in the condenser. In connection with the use of improved types of tubes, he had a condenser fitted in May, 1923, with the following experimental tubes:—

40 copper-nickel alloy..	85 per cent. copper, 15 per cent. nickel
40 copper-tin	95 per cent. copper, 5 per cent. tin
40 brass..	Z metal
40 brass..	70 per cent. copper, 30 per cent. zinc
40 Admiralty mixture	70 per cent. copper, 29 per cent. zinc, 1 per cent. tin.

The results of the failures of the respective metals after four years' use were as follows:—Copper nickel alloy, one tube; copper-tin alloy, nil; Z metal, four tubes; brass 70 : 30, eighteen tubes; Admiralty mixture, one tube. It appeared therefore that tubes containing no zinc or a small percentage were the best for withstanding corrosion or erosion. In that and other tests the 70 : 30 tubes appeared the most unsatisfactory. If the trouble with the tubes was due to erosion, did it not appear that a harder close-grained material was required for the tubes, although they were very much more expensive, owing to the greater difficulty of drawing them? His experience of coating the interior of Admiralty mixture tinned tubes, as manufactured at present, had not been very satisfactory, but at the same time he did not agree with Sir Charles Parsons that coating the interior of tubes with bitumen was only a palliative. Sir Charles did not appear to be aware of the developments in this method of protection, and it was the only simple way out of a difficulty in a time of great trouble. The boilers on ships with coated condensers were running practically fresh, and boiler scaling was down to a minimum. Bitumen had, apparently, all the properties necessary for preventing local corrosion, pitting, electro-chemical action and erosion, and also the property of adhering to the walls of the tube. The coating must be kept very thin and must cover the whole surface evenly. Although Sir Charles' paper was in connection with condensers that leaked owing to the erosion of tubes, it might be of interest to remember that leakage, sufficient to cause serious trouble to water-tube boilers, could be encountered from other sources. In the condensers of geared turbines, leakage was often experienced from the packing being loosened by the vibration of the tube in the stuffing-box, the exciting vibration coming from the gearing. This leakage could often not be detected by an ordinary water test. Leakage of salt water into the feed system might also come from auxiliary condensers, drain condensers, salt water calorifiers and leaks in reserve feed tanks. In connection with Sir Charles Parsons' experiments, he would be glad if he would inform him if he considered the vortex would be reduced if the water were discharged from his condenser against a head, also whether the water, being in continuous circuit and sprayed from the ends of the tubes, was not more aerated than it would be in marine condensers under ordinary working conditions. If so, the quantity of oxygen or air dissolved in the water would have a more deleterious effect. He would also be glad to have Sir Charles' opinion as to the effect of the grid becoming choked with ashes, fish, marine growth, galley refuse, &c., also regarding the possibility of trouble from turbulence in the tubes owing to their being practically choked with similar material. He asked that because several years ago he was of the opinion that corrosion might be caused by the deposit of foreign matter in tubes, and in order to prevent such matter reaching the tubes a wire grid of $\frac{7}{16}$ in. square mesh was fitted inside the inlet end of the water-box. That grid intercepted all matter entering the condenser. Owing to the accumulation of foreign matter between the grid and the tubes, which resulted in the choking of the grid and the choking of the tubes to a greater extent than that previously experienced, and thereby preventing a flow of circulating water with a corresponding drop of vacuum, the grids had to be dispensed with. Sir Charles also stated that corrosion was generally found in tubes at the inlet end. From his experience of the present type of erosion, it could be found in any part of the tube, top or bottom. Regarding the protection of the tubes by counter electromotive force, experience on many condensers had shown that the protection only extended from 3in. to 8in. from the ends of the tubes.

Sir Charles Parsons made a very brief reply, and said that it could be definitely stated that the vortices had a very deleterious effect on the face of condenser tubes. He asked Mr. Cook to say something on the mathematical side.

Mr. S. S. Cook said that he had prepared a number of calculations on the mathematical side as a contribution to the discussion which he would send in for publication. Giving a brief indication of this work, he said that the first matter dealt with was the momentum of the water in the tube; the next was the pressure distribution in a vortex; and the third was the average pressure over a tube mouth, when a vortex was brought immediately in front of it.

Members reassembled at the Royal Society of Arts on Thursday morning, April 7th, when the Duke of Northumberland again occupied the chair.

A paper was then presented by Professor W. E. Dalby on "A Characteristic Energy Diagram from an Oil Engine and the Marine Oil Engine Trials." We give a summary of this paper on page 421.

Oil Engine Energy Diagrams.

Engineer Commander C. J. Hawkes, in opening the discussion, said that he was in rather a difficult position, because he was one of the Institution's representatives on the Marine Oil Engine Trials Committee, and in speaking on the paper it would be impossible for him to avoid disclosing the fact that he did not agree with everything in the reports. With regard to suction temperature, to arrive at that it was necessary to know the pressure and the temperature. The former was determined from a light spring diagram, and those who had experience of taking such diagrams would know how they varied, even when a number were taken immediately following each other. It was possible to get a variation of $\frac{1}{2}$ lb. or 1 lb. per square inch unless they were very carefully taken. Although the author had said that the suction temperatures in the case of the Cape York were a little low, he personally thought they were about right, because in that case the engine was a four-stroke engine of the ordinary type. The Richardson-Westgarth engine, however, was a director valve engine, which, by its design, would cause the suction temperature to rise above that of the ordinary type of engine, because the air had to pass through a

larger valve. That engine would be expected to have a lower volumetric efficiency, and therefore a higher suction temperature. The Still engine was a hot engine; it had hot jackets and the air, as it entered the cylinder, picked up considerable heat, but its scavenging efficiency was not so great as that of the four-stroke type of engine. To assume 70 deg. as the suction temperature for all engines, was to assume that all engines had the same scavenging efficiency. The Doxford engine was one of the best from the scavenging point of view. It was a uniflow type of engine, which worked with a hot piston, but the method of scavenging was such that the air did not pick up so much heat as it entered the cylinder. The conditions were very much the same in the Fullagar engine as in the Doxford engine, but as in the Fullagar the pistons were not so hot, the scavenging efficiency would be expected to be higher than in the Doxford. Therefore, it was not right to take a uniform temperature for the suction of every engine. In other words, "we do not know where we are." What was the use of analysing the exhaust gases? In the case of a two-stroke engine, the exhaust left the cylinder and was followed by scavenged air, which was probably a mixture of exhaust gas and scavenged air, and that was followed by more or less pure air. Therefore, the sample that was trapped was by no means a sample of what was trapped in the cylinder. It might or might not be a sample. Therefore, were we right in taking the exhaust gas analysis to determine the weight of the fluid in the cylinder at the beginning of compression? Exhaust gas analysis was totally misleading in the case of the two-stroke engine. His fault with the Committee was that it should have made any deductions from the exhaust gas analysis in the case of two-stroke engines.

As to the use of the term "semi-Diesel," Commander Hawkes said that we in this country ought to be able to take a little credit for that, and it was time the expression was abandoned. Akroyd Stuart was a year before Diesel, and as soon as air injection was removed from the engine it ceased to be a Diesel engine. That type of engine was really a British engine. He agreed with the author as to the difficulty of getting true I.H.P. because, owing to the conditions in which the cards were sometimes taken at sea, it was difficult to regard them as a true measurement of the power developed inside the cylinder. It was for that reason that no surprise need be expressed that an error was found in the case of the Cape York. The author's method of taking I.H.P. was to be preferred to the ordinary indicator diagram, because he had found that the mechanical efficiency results could easily be shown to vary by 6 per cent. when using indicator cards. Where the author had given results of B.H.P. against fuel oil per minute, it would have been better to have given B.Th.U's. per minute, because that brought in a point of great importance in the case of such an engine as the Doxford, and on that basis the Doxford engine would show better results, because that engine used fuel of a higher calorific value. Another point was that low calorific value fuels were difficult to burn, and if all the engines were put on the same fuel there would be an appreciable difference in the figures obtained. As regarded the ideal efficiency referred to in the paper, he personally did not consider the old air standard for such engines as these as the best. He would not say it was useless, but it was not the best, and he felt that if we did need an ideal standard for the comparison of all types of internal combustion engines, then we should adopt the old Atkinson cycle, which assumed a constant volume of the combustion and constant pressure rejection. That was the most to be got out of an engine, and by taking that cycle we should be doing what we had, in effect, been doing for many years with the steam engine, in taking the Rankine cycle as the cycle of comparison.

Mr. W. H. Patchell, as Vice-chairman of the Marine Oil Engine Trials Committee, regretted the reasons which had prevented the Chairman, Sir George Goodwin, from taking part in the discussion. The work of that Committee, he said, was to find and report facts and to keep off controversial ground, such as making comparisons certainly was. No one, however, was better fitted for the task of making such comparisons than Professor Dalby. It seemed to him, however, that there was not so much controversial matter on the naval architects' side as on the mechanical engineering side. The Committee, however, would welcome the collecting, computing and reviewing of the naval architects' special trial esults by such an authority as Mr. Baker, who could be relied upon to keep off controversial matters and give a paper of very good value.

Mr. G. J. Lugt, of Amsterdam, said that, if the results were plotted out the way Professor Dalby suggested, any errors or mistakes could be detected at once, during the trials, and, if possible, the errors could be eliminated in time. One of the most difficult problems was to get an absolutely accurate figure for the I.H.P., however simple that might seem, even given the very accurate and highly developed instrument possessed in the indicator, especially at the speeds dealt with in this case. He then referred to the obviously erroneous figures found for the I.H.P. in the case of the Cape York's engines of Werkspoor design, as he was responsible for the construction of the Werkspoor engines in Amsterdam. In a general way, when testing an engine of any description, it was, of course, of primary importance to work with verified and accurate instruments, and he did not doubt that the instruments used by the Committee were all that could be desired. If faulty results were arrived at all the same, it could only be due to the indicator gear and its component parts, and he thought that a thorough verification of them should be made before the trials were started. Unless the stroke reduction was taken directly from the crosshead, we were, in the case of the four-cycle engine, almost obliged to derive the motion from the cam shaft running at half the engine speed. A very common method, also used in the case of the Cape York's engine, was to fit adequately shaped double-nosed cams, and it could easily be shown that an apparently insignificant error in the cutting and setting of the cams had a very pronounced influence on the shape and area of the cards. His firm had special machinery for grinding and accurately setting these cams, which should give reasonable certitude that both were right. There were, however, other influences which affected the card; the size of the hole in the indicator cock and the length and width of the connection with the cylinder, and notably the lead from the gear to the indicator. He had made some calculations and experiments lately which indicated to what extent those factors were of importance.

Lantern slides were exhibited showing the effect of advancing and retarding the cam, and the influence at various mean pressures and the influence of stretching leads. This latter was shown to be comparatively small as far as the area was concerned, but very long leads and unstable supports had a very marked influence, as indicated by a number of cards taken on the same cylinder, at the same load and speed.

Engineer-Commander Turner was inclined to doubt whether Professor Dalby's estimates of the air consumed were even approximately correct in the absence of direct measurement, based as they were on assumed volumetric efficiency and temperature of suction air, whilst neglecting all losses of air through the exhaust valves or ports. Moreover, the calculations assumed that the air compressed was fresh air. In the case of fast-running high-duty engines, that was not true, as tests carried out on samples of the air actually under compression showed that the contamination of this fresh air might be of the order of 8 per cent., owing to the presence of foul air. That indicated that the compression space of the four-stroke engine was not completely scavenged under the conditions obtaining at high speeds. In certain two-stroke engines there was no doubt that the contamination was more than that. The comparison of pressures was of interest, as it was the object of engineers to reduce the ratio of maximum pressure to mean indicated pressure as much as possible on account of scantling considerations. At the high powers mentioned in the paper, it had been reduced to 3·4, compared with the ratios of about 6 quoted by the author. The terminal pressures, on the other hand, were not so low as in the vessels that were now so well known. If those were measured at the moment of the opening of the exhaust valve or port, they might, in the naval engine, be three times as much as those in the merchant ships. That gave some idea of the wear and tear difficulties which had to be faced. The wear must be reduced to a minimum, and that was being closely studied, but at present it might be stated that the wear of cylinder liners of high-speed naval engines was in no sense inferior to that of the best motor practice. Experience showed also that the better the combustion, the less was the cylinder wear and tear, and there was distinct evidence that under the conditions obtaining, the gases of incomplete combustion did exert a steady reducing action on the structure of the steel. The heat carried away through the piston was about one-quarter of that carried away through the cover and jackets combined. That pointed to the necessity of making pistons as thin as possible, and of materials possessing high qualities as regarded conductivity of heat, otherwise piston trouble might be anticipated. The modern aluminium pistons of Y alloy had not given the slightest difficulty under conditions ranging up to over 200 lb. per square inch mean indicated pressure, the rings being clean, free and well lubricated with no signs of wear in any particular over periods of many weeks' high-power running. On the other hand, difficulties had arisen with pistons in a two-stroke double-acting engine of high duty, as the heat flowing to the piston might be as much as three-quarters of that taken away by the jacket cooling water. Whether that unexpected increase was due to difficulties with scavenging at high speeds, or to unusual piston friction, or the two combined, had not yet been cleared up satisfactorily. Further trials would be resumed shortly, which would probably throw more light on that point. The quantities of air allowed per pound of fuel by Professor Dalby were not in agreement with high-speed practice, as it seemed that much more air than he allowed for might be required. Professor Dalby's remarks on the errors involved in the estimate of air supplied as deduced from the quantity of CO_2 in the exhaust gas he fully concurred in. The proportion was also very susceptible to the rate of forcing of the engine. For example, with a series of trials ranging from 250 to 450 B.H.P., the average percentage of CO_2—by volume—rose with the power from 6 to 10¼ per cent.—12¼ per cent. having been recorded—whilst at the same time the oxygen content percentage fell from 11½ to 5½ per cent.—the lowest percentage recorded by 4½ per cent. He did not altogether agree with Professor Dalby's definitions of the four types of engine under consideration. They appeared to be insufficient. In the two-stroke engines the author should differentiate between the method of arranging the air and exhaust ports, and some such term as "axial" or "through-scavenging" should be given to the Doxford and Fullagar engines, "transverse" scavenging to engines with the parts arranged as in the Still, Sulzer engines, &c., and possibly "positive" scavenging to the four-stroke engines.

Mr. W. J. Still agreed with Commander Hawkes as to the difficulties of measuring suction temperatures, particularly in two stroke engines, although, he said, a fairly good indication of it could be obtained in the case of the four-stroke engine. It was to be remembered that the volume of the clearance space was a very big factor in the consideration. He had found that the temperature of charges in internal combustion engine cylinders depended more upon the amount of exhaust gas which was trapped in the cylinder, and which mixed with the charge, than upon the heat from the cylinder walls. It was a question of heating up the mixture rather than heating by contact. In his own case he had made a number of tests by withdrawing a large proportion of the charge from the cylinder during the working of the engine, measuring the difference in compression to get an idea of the proportion of charge abstracted, and then weighing the actual quantity of air removed. It was impossible to lay down hard-and-fast laws as to what was the charge weight in a two-stroke engine, judged, by light spring cards which were very difficult to produce accurately, and by the assumed temperatures of the gases. The fact was often overlooked that in the case of a two-stroke engine a great deal depended upon the completeness with which the products were exhausted from the cylinder; in other words, how low the pressure was reduced in the cylinder by the rush of the exhaust gases before the scavenge air began to come in. If exhaustion to 7 lb. were carried out there would be very much less weight—and it was weight which counted—of exhaust gases remaining to contaminate the new charge. That was a very important factor and one which differed with every type of engine. Commander Hawkes had been a little hard on the indicator, and he himself felt that the fault was more often with the way it was applied. He certainly thought the method adopted by the Werkspoor people was one which was open to cause very serious error. Having fitted up a number of engines with cam drives, he had in all cases had to take the drive out again and replace it with one of the more generally accepted forms. The trouble was largely with the spring in the lay shaft, because the lay shaft did not revolve synchronously with the crank shaft.

Mr. J. H. Narbeth said that the paper provoked many thoughts. For instance, the Doxford engine gave 4·4 B.H.P. per ton weight with an air mixture of 24·6 to 1, while a mixture of 14 to 1 would be sufficient if complete combustion could be obtained. That indicated the theoretical possibility of using cylinders of much smaller volume, and therefore of still less weight for the same power. The comment as to the relatively high mechanical efficiency of the two-stroke engine required further explanation. That high efficiency was perhaps partly due, in the Doxford and Fullagar engines, to the opposed-piston system, with good balancing and long connecting-rods, and not altogether to the fact that the engines worked on the two-stroke cycle. Calling attention to a few other points, Mr. Narbeth said that the B.H.P. thermal efficiency for the Dolius reached the remarkable figure of 37 per cent., so that the Scott-Still engine was apparently the most economical prime mover that had yet been produced. The Committee's report on the Pacific Trader showed that the Doxford engine possessed outstanding merits in the efficient consumption of fuel of boiler oil quality, a matter which might influence the cost of running in a most appreciable manner if experience on service brought no evil results. It was to be regretted that sea-going trials were not possible with all the ships loaded down to something like ordinary sea-going conditions, and run with clean bottoms. Such trials would add immensely to the value of the records available for owners, builders and designers. It was most urgently necessary that the owners of the vessels should supply authoritative reports on the experience gained with the vessels at sea, as to the maintenance of low fuel consumption, the practical demands for oil for lubrication and the general cost for repairs and maintenance.

Mr. C. W. Taffs, after expressing the opinion that it would have been better if the author had used the designation of the engines instead of the name of the ship, as already the Sycamore had been re-named the Prince, said that the expression for density $D = P/96\,T$ assumed perfectly dry air. As the amount of moisture found to be present in the atmospheric air during the trials was of the order of from 0·7 to 1·25 per cent., the magnitude was sufficient to be taken into account in any computation affecting density. Further, the different trials of different engines took place during various sorts of weather and atmospheric temperatures, and that fact also had an effect upon the charge weights of air which influenced the figures arrived at. He did not agree with the plan of adding the electrical

input to the scavenge blower to the I.H.P. to get an overall plant efficiency because the blower was of sufficient size for two engines. Had a size of blower suitable to the engine been installed, no electrical energy would have been required. On the other hand, had the electricity been generated by the engine, the amount of fuel would have been more than was represented by the actual volt-ampères recorded as input. In making a comparison between the Doxford and the Fullagar engines, the fact should not be lost sight of that the Committee's trials of the former were run on boiler oil, whilst the Doxford trials were run on Diesel oil, and, although the fuel nozzles were unaltered, that engine showed a fuel economy practically equal to that of the Still engine.

Professor Dalby, replying to the discussion, said that nowhere in the paper had he dogmatised with regard to suction temperature. When the work was started, failing any knowledge of suction temperatures, he had had to fall back on the knowledge he had and guess at something. He had guessed at 70 deg. Cent. from work he had done, and actually measured, and from those measurements he found that the Cape York was not very far out. He had also pointed out, in the paper, that it is possible to estimate the weight of air from the exhaust gas analysis, but the error likely to be introduced was large, because the estimation was on only a small fraction of the total contents of the product. A good many of the remarks had been directed to the impossibility of getting that, but he was not quite so pessimistic. He did not suggest that it would be ascertained to ½ per cent., but it could be obtained with sufficient exactitude for most engineering purposes. He agreed with Commander Hawkes as regarded the use of the term "semi-Diesel." There was a Committee appointed to try and get proper terms used, but in spite of the work it did, one of the members said that he should continue to use the term "semi-Diesel." As to giving the results in terms of thermal units, that was very difficult, and, after all, we paid for oil and not thermal units, and for that reason he thought it better to plot what was paid for. He did not agree with Commander Hawkes as to the use of the Atkinson cycle, because he did not regard it as one applying to the internal combustion engine.

Mr. Summers Hunter, who occupied the chair during the latter part of the meeting, remarked that vessels were now fitted with oil engines and the vessels went straight to sea without any extended trials, owing entirely to the fact that the oil engine had reached such a state of perfection and reliability. Nevertheless, there was still room for full-scale trials which would make for improvement in the reliability of oil engines, and he hoped that owners would look at the matter from that point of view more in the future.

The discussion closed with a cordial vote of thanks to Professor Dalby.

The first paper taken at the afternoon sitting was entitled "Notes on the Design of Coasters," and was by Mr. J. Douglas Calder. The following is a *précis* of it :—

NOTES ON THE DESIGN OF COASTERS.

The term "coaster" is confined in this paper to vessels of the raised quarter deck type, ranging in length from 100ft. to 210ft., with the propelling machinery placed aft. The dimensions of between two and three hundred recently built coasters are classified according to length, and are embodied in a table giving the average dimensions of length, breadth and depth, and the maximum, mean and minimum lengths divided by breadth values for grades increasing by 10ft. from vessels between 100ft. and 110ft. long to vessels of 200ft. to 210ft. At the 140ft.–150ft. grade, and again at the 200ft.–210ft. grade there is a break in the otherwise steadily increasing proportion of length to breadth. The breaks are due to two classes of exceptionally beamy vessels built in fairly large numbers. The average speed-length ratios of a number of designs are also tabulated and are plotted in curves against block coefficients. In most coasters the machinery comprises a single set of triple-expansion engines with surface condensers and 180 lb. main boilers ; while in smaller ships compound engines and boilers designed for pressures of 120lb. to 140lb. are often employed. It is remarked by the author that trial trips of coasters are often carried out in a very cursory manner, and that progressive trials, especially in a loaded condition, are unfortunately uncommon. Some results of progressive trials for six vessels A to F are given and are plotted on the form of curves relating the speed length ratio $V/\sqrt{L}$ to the Admiralty constant $D^{\frac{2}{3}}/V^3$ divided by I.H.P. Reference is made to the lack of data in regard to coasters, especially model data, and the question of wave making resistance is discussed. Tables are given of suggested block coefficients and mid-area coefficients for coasters. The corresponding priamatic coefficients vary from 0·77 for $0{\cdot}68\ V/\sqrt{L}$ to 0·65 for $0{\cdot}92\ V/\sqrt{L}$, but do not vary with change of length over breadth proportion, the necessary increase in fineness being obtained by reducing the mid-area coefficient. The block coefficients suggested are considerably finer than those which are generally in use for coasters, and are also rather fuller than those now considered suitable for ordinary merchant vessels of corresponding speeds. With finer coefficients, the loss of deadweight outweighs the advantages obtained from extra fineness. In conclusion, a suggestion is put forward for more easily freeing the decks of raised quarter deck coasters from water, by replacing portions of the plate bulwarks in the well and on the raised quarter deck by open rails and stanchions, sufficient protection being left to prevent water from finding its way into the engine-room and boiler space and accommodation. An excessive height of well bulwark would seem to make it possible for the well to retain a dangerous amount of water. The arrangement of two types of coaster designs with overall lengths of 130ft. and 164ft. respectively, is illustrated, and particulars are given of points in the analysis of the vessels examined upon which differences of opinion existed.

Sir John Biles, in opening the discussion, said that the design of a small ship was very often more difficult than that of a large ship because, in questions of form, speed and stability, more care was necessary, inasmuch as small variations might make considerable differences in the results. As a matter of fact, the subject of the investigation of forms of small ships was receiving the attention of the Tank Committee, at the hands of Mr. Baker, and the results when published would be extremely interesting. Actually, he did not think the lack of information was so great as the author had suggested that it was. It seemed, rather, that the author had looked at the question from the point of view more of fixed block coefficients, which had become standardised in the construction of coaster ships, than was absolutely necessary, as it seemed to him that those full forms were not necessary for coasters. Mention had been made of sacrificing deadweight by fining the vessel, but it was possible to make a vessel of finer form which would carry the same weight, though it could not be done with the same dimensions. Then came the eternal question of whether the commercial efficiency of the finer, and perhaps more expensive vessel, was not greater than that of the cheaper and fuller vessel, and that was a matter for investigation in each particular case. He had known of cases—extreme cases, perhaps—in which a larger hull and finer form had been associated with reduced horse-power and had led even to reduced first cost.

Mr. G. Foster King said that it was inaccurate to suggest that there were no data available concerning coasters. It would have been more correct to say there were no published data, because if there was one class of ship more than another that the builder knew all about it was the small coaster, for the small coaster was the whole history of iron shipbuilding. In vessels such as they were it was desirable not to have a quarter deck of the cistern type, which retained water at that level, having in mind the small range of stability and small freeboard, and he would have thought it would have been to the advantage of the owners and builders to make sure that water could not be bottled up over so large an area as the length of the quarter deck covering more than half the length of the ship. It would be far better to make a free passage on each side by having wide open rails in place of bulwarks. Seamen would not go to sea in a vessel with solid bulwarks in the well, because of the discomfort in moderate weather, and the obvious thing to do was to provide hinged bulwarks or something of the kind. In that connection, extreme care must be taken to see that the water had not access to the engines and boilers, and the provision of rails instead of solid bulwarks had a bearing in that connection.

Mr. R. Williamson said that to employ a coaster profitably it was important for the model of the vessel to possess good sea-going properties, and particular attention should be paid to the propeller to enable the vessel to make her passages between port and port in bad weather in the shortest possible time. His experience in building, designing and owning various sizes of coasting steamers, extended over thirty years, and from experiments made on trial trips and progression runs, sufficient data had been obtained to prove the advantage of increased surface on the propeller blades, and a reduction in revolution of the engine. There were many other items in the design of coasters that were important ; for instance, every owner desired to obtain the largest cubical capacity of his hold in relation to the deadweight, and the lowest net registered tonnage upon which port charges were levied. The machinery in coasting steamers being placed aft required careful consideration in the design of the model ; the weight of the machinery was much less important than the displacement of the machinery space, and the distribution of the water ballast tanks was a most difficult problem. The author had referred to the recent disasters to coasting steamers, and made suggestions respecting the freeing ports in the bulwarks. Whether plate bulwarks or open rails should be fitted, was a very controversial matter, upon which there was a diversity of opinion between masters and officers who navigated the ships. In a well-designed model that had good sea-going qualities, however, very little water came on the raised quarter-deck if 4ft. above the main deck level. Some years ago he investigated the cause of a tarpaulin being washed off the after-end of the hatchway in the fore-well, and found that it was due to defective design of the hatch wedges. Since then, in every vessel, he had built the hatch cleat at the same level as the wedge. It was possible that the cause of many of the missing coasters was that the hatch wedges washed out. The hatch wedge had the same duty to perform as the key in the chairs that kept the rails in place on railways, and if the same care was taken on board ship, especially in the fore well, as the railways took, there would be fewer disasters. Finally, Mr. Williamson gave a few figures of results obtained which demonstrated the value of tank experiments, and justified the expense involved. His view was that vessels were often over-engined, and the instance quoted bore out the view that full work was not being obtained from the engines in many cases.

Mr. A. L. Ayre asked whether the author's intended interpretation of "designed" speed, was the speed on trial or on service ? The formula for block coefficient, to which he referred last year, applied to the former, being the condition closely corresponding to the tank experiments. He was unable to say to whom we were indebted for the general construction of the formula which, although of long standing and originating before there was much published material concerning model experiments, was undoubtedly very sound. It presumed, of course, normal relation with midship area, and therefore the prismatic coefficient, but that was rarely the case in small vessels, the bilges of which were frequently relatively fine. The author suggested that that class of small vessel might, with advantage, be made of finer form than was customary, and he fully agreed with him. It would seem that there was a general feeling that the economic importance of deadweight in such vessels was greater than that of the cost of propulsion. In the case of small vessels, the deadweight coefficient DW/Δ was relatively small—and it also fell very rapidly as size was reduced—and while there was something in the idea of obtaining high deadweight, it was generally carried too far. It had also to be remembered that those vessels had displacement-length ratios, which, in relation to their speed-length ratios, were most abnormal, *i.e.*, those small vessels were excessively stumpy. The association of the very full block coefficient with the excessive degree of stumpiness was, he believed, a more serious aspect than a consideration of the coefficient in connection with the proportion L/B. The curves of the Admiralty coefficient mentioned in the paper would have been of greater interest had they been accompanied by the actual dimensions of the vessels. That would have permitted of comparison taking into account the effect of size, which the Admiralty formula in itself failed to do, and for such small vessels the size effect on the Admiralty coefficient was very sensitive, and might therefore be misleading. For instance, although the curve A A A in the paper occupied a relatively low position in the diagram apparently, primarily, owing the excessive fulness of the vessel—having regard both to the block and prismatic coefficients—it would appear that the vessel was economically suitable for a trial speed no higher than about $V/\sqrt{L} = 0{\cdot}62$, and for the full range of the curve as illustrated, the vessel was therefore considerably over-driven. It was not possible to tell to what extent the values in that case were low, whether because the vessel perhaps was smaller than the others, or whether it was due to some other abnormal feature. I.H.P. at corresponding speeds for vessels of identical form and proportions, although differing in size, and with normal efficiency of machinery and propeller, varied closely with $\Delta^{0{\cdot}56} \times V^3$, a much slower rate than $\Delta^{\frac{2}{3}} \times V^3$. The use of that amended numerator in the Admiralty formula would, for all practical purposes, eliminate the size effect, and, while the resultant coefficients were of entirely different magnitude, the effect on a diagram, such as shown in the paper, would be to illustrate more clearly the remaining variation arising from differences in form and proportions of the various vessels. It would be useful to know if any of the vessels referred to in the paper were fitted with fenders, which might seriously affect the resistance.

Mr. G. S. Baker said that the paper showed how little builders of the type of boat under consideration really knew with regard to what was wanted in the shape of hull and propellers. Even to-day it was possible to find 30 per cent. difference in propulsive efficiency between one vessel and another, each one turned out having behind it the best knowledge of the people building it. The paper said nothing about propellers, and, personally, he believed that there was quite as much in the shape of the propeller as there was in the shape of the hull.

Mr. Calder, in his reply to the discussion, said that, in referring to the lack of data, he had in mind the lack of published experimental data ; he was aware that a certain amount of other data was available. As regarded Mr. Ayre's remarks, when discussing maximum surface speed, he did not refer to measured-mile trials because very few people placed any reliance upon them ; but to trials over a course of, say, 10 knots, with two runs each way in average Bristol Channel weather. There was an important consideration why block coefficients were made very much more full in the case of coaster vessels than in the case of the average vessel. Taking a case from actual practice, a vessel 175ft. in length made runs of 270 nautical miles, and was supposed to do the journey in thirty hours, or at 9 knots. The speed length ratio was 0·68. If that boat was delayed three hours it was necessary that it should be able to do the trip at 10 knots to get into port at the same time. In other words, the speed/length ratio was increased to ·76. The percentage of time the vessel was engaged at full speed was 37 per cent., and he had known it to be less, and that was why the block coefficient had to be higher than in the case of other vessels. In the case of a boat 410ft. long which ran a journey of 3300 nautical miles, the trip was supposed to be done at 13¾ knots, and supposing that boat were delayed a whole tide—twelve hours—the increase in the speed/length ratio to enable the vessel to arrive in port at the same time was negligible compared with the coaster. In reply to Mr. Foster King, Mr. Calder said that the real point was not that builders of small vessels knew exactly what the vessels were going to do, but what those vessels could do if they were properly designed.

The next paper was on "The Future of Sailing Vessels Fitted with Auxiliary Motors," by Captain

Chr. Blom, of which the following is a brief summary :—

THE FUTURE OF SAILING VESSELS FITTED WITH AUXILIARY MOTORS.

This paper is a plea for the renaissance of the sailing ship in the form of a fast passenger carrying vessel fitted with fully rigged sails and auxiliary motors. It is claimed by the author that such a ship might attract tourist traffic, as many people who enjoy life at sea would prefer the more interesting experience of travelling on a fully rigged sailing ship, to a liner provided that similar comforts were provided and fast passages could be made. The design is worked out for a four-masted barque of about 300ft. in length, and the resistances and speed calculated. The resistance figures are compared with those three representative clipper ships, the Lightning, Thermopylæ and Cutty Sark, and a modern steel sailing ship, the Pola, built in Hamburg in 1916. With a wind of about 21 m. per second or a force of 9 of Beaufort scale, the expected designed speed of the proposed ship would be 20¼ knots to 20½ knots. A 450 S.H.P. motor, giving the ship a speed of, say, 8½ knots, would be fitted with probably an electric drive. Electricity would also be used for working the sails, for deck auxiliaries and for heating, ventilating and cooking purposes. An itinerary is given—a year s sailing of such a vessel, including voyages from Plymouth to Melbourne and New York, and trips in Scandinavia and Mediterranean waters, and operating costs and receipts assuming a crew of 58 men and 65 passengers are worked out. It is suggested that motor sailing ships should be built and run if our skill in designing and handling sailing vessels is not to be lost. Also it would be well not to be unprepared for the day when the need for sailing ships may become pressing owing to the operating costs of engine-driven ships proving too costly.

Only three people took part in the discussion of this paper, and the remarks of each of them could be epitomised in the statement that they expressed considerable doubt whether a sailing vessel, 310ft. long and 45ft. wide, fitted with sails and auxiliary power to carry fifty first-class passengers, would prove attractive to those wishing to take pleasure cruises, and that, consequently, it was extremely doubtful whether such vessels would prove to be paying propositions. Dr. P. E. Hillhouse suggested that the only chance for such a vessel would be if the world's future supplies of fuel were in some way practically to disappear. Sir John Biles and Mr. Walter Stewart were the other two speakers, who took that point of view. Another point raised was the advisability of even subsidising one or two vessels of the type in order to provide really suitable training in seamanship for boys. It was apprehended that the present state of the finances in this country would prevent any such scheme being put into operation here, but it was hoped that we should not leave the sailing vessel entirely to continental competitors. The rather interesting psychological point was made by Dr. Hillhouse that the tours which have been made popular by steamship companies had their attraction rather in the places visited and the time spent ashore, than in the time spent on board ship, and he doubted whether people attracted in that way would feel altogether happy if compelled to remain on a small sailing vessel for long periods at the mercy of the elements.

The author, however, stoutly defended the proposals in his paper in the course of his reply, and expressed the belief that there were circumstances under which such vessels as he had dealt with in his paper could prove commercially profitable.

At the evening session, under the chairmanship of Sir John Biles, a paper on "The Design and Construction of High-speed Motor Boats" was read by Mr. David Nicolson.

DESIGN AND CONSTRUCTION OF HIGH-SPEED MOTOR BOATS.

The type of boats considered are divided into three distinct classes, and the evolution which has taken place in each type is described. The types include boats with fast displacement hulls, V-bottom hulls, inverted V-bottom or sea-sled hulls, multi-step and single-step hydroplanes. Typical lines for each class of boat are given, and an appendix gives in tabular form the dimensions, power displacement, speed, and ratios of displacement to speed, and beam to length. Special hulls designed and built by S. E. Saunders, Ltd., of East Cowes, are mentioned, including a displacement hull with a bulb-shaped bottom and a sea-sled hull with a tunnel in the centre of the boat's bottom, to obtain larger air collecting powers for cushioning and to improve directional handling qualities. Having reviewed the relative advantages of each type, model tank tests are next considered. Model tank tests have never been used extensively for small boats, mainly because of the high relative cost, as the work entailed in testing the model of a 30ft. boat is very little different from that with a model of a 600ft. ship. However, if a small one-design class, or standard boat, were to be produced, it might be an advantage to carry out model tests rather than finish the boats and then make changes in order to get the best combination of hull, motor, and propeller.

Model tanks tests are at times of great value, but they have many restrictions, especially for boats with speeds of 50 knots and over. The first limitation is the speed of the present tank carriages; secondly, the models being so small, a high degree of accuracy in the measurement of small forces becomes very difficult. Again, rough water trials, even with wave-making apparatus, do not give accurate results of porpoising, or show how considerable the spray would be, and as the model is confined to a straight run it does not yaw as it does in practice. For boats of very high speeds it is the writer's opinion that wind tunnel tests would prove to be very valuable.

The advantage of the hydroplane type of boat over the round bottom boat is illustrated by actual tests of a 30ft. of each type over a ¼ knot measured course; 100 B.H.P. engines were fitted. At engine speeds up to 1000 to 1400 revolutions per minute the speeds obtained were similar, but over 1600 revolutions per minute the hydroplane started to plane and the speed rose from 23 knots to 28 knots. The author regards it as inadvisable to add more power to a round bottom beyond a speed-length ratio of 3·8.

Many countries realised the great value of high-speed motor boats in the late war, and they are now giving these types of vessels a thorough testing. Foreign navies at one time came to this country for their pioneer boats, but unless we show that we are making evident progress they will go elsewhere. One of the most important factors we must not lose sight of is the training of *personnel* of high-speed work. The design and construction of high-speed motor boats proved to be exceptionally valuable previous to the late war, as all flying boat hulls were practically evolved from our hydroplanes. No doubt the data obtained from fast boats will have a great influence on the design and construction of flying boats and seaplanes in the near future.

In the discussion which followed, Sir John Thornycroft said that as the author had mentioned the multi-step hydroplane, and had referred to Monsieur Fauber's name in that connection, he would like to add the name of the Rev. C. M. Ramus, who, fifty years ago, urged the advantage of a boat that would skim, and one of whose original models he was able to exhibit to the meeting. Mr. Ramus worried Parliament and the Admiralty to take up the matter as being of enormous importance, and he did succeed in showing, as far as was possible at that time, the advantages of such a craft. Showing some other models, Sir John referred to a paper read before the Institution in 1923 by Lieut. Bremner and himself on "Coastal Motor Boats," in which were given results with different types of boats tried before the C.M.B. was standardised. The curves given in that paper showed that the best boat was the single-step boat, the sea-sled was somewhere in the middle, and the ordinary V-bottom boat was very much the worst. It was not thought worth while, however, at that time to try the multi-step boat, and the conclusion was that the possibilities would lie between those different types. Another model which Sir John showed was of one of the single-step boats which were forerunners of the C.M.B.—a model of the Miranda III., which in 1910, in an officially recorded trial, did something over 35 knots with quite a moderate power. In differing from the suggestion that the single-step boat could not be a good sea boat, Sir John said that a compromise had to be made between a perfectly flat boat and a certain amount of V-bottom, and in that connection he drew attention to the fact that, although the C.M.B.'s had to keep at sea during the war in all weathers, he never heard that one of them was lost by capsizing or anything of that kind, while there were occasions when the narrow step boat was turned over. One statement in the paper he felt bound to contest, for although one was naturally anxious to see British exploits in the forefront, statements in the records of the Institution should be strictly accurate. In the paper it was stated that Maple Leaf VII. attained a speed of 83 miles an hour, thus acquiring the title of the world's fastest motor boat. But it was generally accepted—perhaps reluctantly, he thought—that the highest record for speed for any skimming boat was held by America—an officially recorded speed of 80 miles an hour over a measured course. He believed that that particular boat had four Liberty engines.

Miss E. M. Keary, referring to Mr. Nicolson's remarks about multi-step boats, said that she did not know whether he had ever noticed whether, in the multi-step type, when under way, all the steps were in action. Generally, the problem of longitudinal stability with a flying boat was harder than with a motor boat, because of the light displacement at high speeds. It had been found quite possible to design such boats to run steadily without the air control being exerted, provided the steps were correctly placed, both with respect to each other and to the centre of gravity.

Mr. E. Wilding, referring to the models, said that there was one type of motor boat which might come under any of the five classes mentioned by Mr. Nicolson. The French brought out, shortly after the war, a skimming boat which had a big aerial propeller instead of a water propeller, thus avoiding the fouling of the propeller in rivers where there was much weed. Some high speeds were obtained, and loads of approximately a ton were carried under comparatively moderate powers. With regard to the strength of the hulls in the displacement type of boat, he had had rather an interesting experience just over twelve months ago. There was at one time—1906–7—a famous boat of that type racing at Monaco. She had originally a 240 H.P. engine. When she ceased to be a successful racer in Europe, she was bought and taken out to South America, and three or four years afterwards a 90 H.P. engine was put in. Later, she was bought by another owner, who put in a 300 H.P. engine. During his visit to South America last year the speaker had occasion to cross over to the coast of Uruguay, and he used that very boat, by that time twenty years old, and it covered 56 kiloms. in an hour and two minutes.

Mr. F. Shepherd asked what were the average propeller speeds of the hydroplanes mentioned by the author, and added that if there was a considerable curve of bow, it would be a means of lessening the spray trouble by throwing the spray down and away from the boat.

Sir William Berry said that, when the war started, the Admiralty, of course, required fast motor boats for many services. The vessels had to be of relatively small size, they had to carry gun or torpedo armament, quite big speeds were wanted, and it was necessary to carry quite a lot of petrol. The racing type of boat was clearly unsuitable for the purpose, and the Admiralty tried ordinary displacement boats, the C.M.B., which Sir John Thornycroft's firm had introduced, and the sea sled which had been referred to that evening. The ordinary displacement boat of the required dimensions was found quite unsuitable. When speeds of over 30 knots were reached, the power required increased out of all proportion. The ordinary displacement boats also showed a strong disposition to dive under and sink. The C.M.B.'s which they had from Messrs. Thornycroft, however, gave remarkable performances from the very first, notwithstanding the fact that they carried a considerable weight of armament. Giving figures typical of the performances obtained on trial under Admiralty inspection, Sir William said that, when the Admiralty inspected the speed of boats, it generally, for some reason, came out a little bit short of what they had been promised or what other people had measured. The figures given for the C.M.B. showed speeds of, in one case, 40 knots, and in another 36½, the boats being 55ft. and 40ft. long respectively, with a petrol capacity of 350 and 150 gallons, and an armament load of in the one case 3000 lb. and in the other of half as much. When, however, they tried to develop a larger boat of 70ft. long, no very great success was obtained. The investigations were hindered by the war, and he thought only one of those larger boats were built. The Admiralty experience of the sea-sled form was rather unfortunate, although that was not due to any particular defect in the type. In 1916 a sea sled was purchased in the United States and a speed of 35 knots was promised. Unfortunately, when it had the Admiralty representatives on board it gave only 31·6 knots. The boat also caught fire several times, and was finally burned out. In 1916, also, two 50ft. sea sleds were ordered by the Admiralty, again from the United States. The stated speed was 38 knots, the speed obtained on trial was 34·4 knots, when loaded in trial condition, and 36 knots when unloaded. Those boats, however, did not come into the Admiralty service. One was also built in England, which obtained a speed of 26 knots with a displacement of 4·6 tons. The disadvantage of that type of boat, apart from its poor sea-keeping qualities, was that the weight had to be kept aft, owing to displacement considerations, and a semi-immersed propeller was inevitable. Although it was claimed that the loss of efficiency with that type of propeller was compensated for by the absence of certain resistance, the arrangement was not one that commended itself to him.

Mr. Hobbs said that for twenty years he had experimented with self-propelled models of very high-speed boats, and had found it possible to record with accuracy—using the word "accuracy" in the general sense—the steam pressure, the number of revolutions per minute of the engine shaft, which in a self-propelled model corresponded to that of the propeller, the distance travelled, and the time. The highest speed obtained with a model 40in. in length was 41·8 miles per hour over a continuous run of half a mile on a circular course, and the engine speed was of the order of 3000 revolutions per minute. He thought, however, that the limit of speed had been reached with the self-propelled models, because of the difficulty of maintaining the thermal efficiency of a blow lamp which was employed.

Mr. J. H. Lower suggested that the author did not seem to attach the importance to tank testing that might have been expected, especially when dealing with high-speed craft. Tank tests obviously had to be paid for, but there were opportunities available at the present time for tank testing to be made at reasonable prices. Even with the present-day tank, 75 per cent. of the boats in the five classes which Mr. Nicolson had given in his paper could reasonably have been tested as models, and the smallest would have been 2ft. long. It was difficult, of course, to reproduce in the tank rough water conditions, but that did not prevent an indication of the boat's condition in choppy water being obtained. The value of tank tests still had to be estimated for seaplanes and flying boats, however, and some more accurate means was necessary for separating skin-frictional from wave-making resistance.

Mr. J. L. Giles expressed some disappointment with the paper because he had hoped that the author would have ventured on a little more of the theory underlying the design of the hydroplane. What basis had Mr. Nicolson used in correlating the model tests to the full size? From an analysis of the resistances of these boats, it seemed that eddy-making resistance was the only one of the sub-divisions as applied to displacement ships which could be applied to hydroplanes in the ordinary form.

Mr. John H. Narbeth, after paying a compliment to the British racing motor boat builders generally, said that he felt great admiration for the skill, courage and persistance which enabled S. E. Saunders, Ltd., of Cowes, to produce such splendid craft as the Ursula. As to Maple Leaf IV., that was now a matter of history, but it would be well worth while adding some details of her actual construction and machinery to the paper.

Mr. David Nicolson, replying to the discussion, said that he had been afraid that high-speed motor boats in this country were going back, and if that had been the case, flying boats and seaplanes would go back with them, but the discussion had to some extent reassured him. Sir John Thornycroft seemed to take some exception to his statement that the single-step boat was a bad sea boat. He had not intended to give that impression; all that he had said was that it was not so good a sea boat as the multi-step. The value of the multi-step was shown in Maple Leaf IV., which Mr. Narbeth had mentioned. That boat was fifteen years old, and still held the sea

mile record. It brought back the B.I. Trophy from America in 1912, and defended it with the same result in 1913. No single-step boat could go out on the days that Maple Leaf IV. went, and put up a speed of 47 knots. Sir John had doubted his figure of 83 miles an hour as the speed of Maple Leaf VII. He knew that Sir John, like himself, was anxious that Britain should always be in the front, but in this case he need have no misgivings, for the figure was that given by the Americans themselves. Miss Keary had asked whether it had been observed if the multi-step boats were only on two steps or were on all steps. The attempt had been made to get slow-motion films of the action ; it had not been successful, but from what had been taken they knew that the boat was running on all the steps. Mr. Shepherd had asked what speed the propellers of the model boats were running at. Assuming 240 H.P., the engine was running at 1400 r.p.m., and the propeller turning at 2100. Last year the Americans sent two boats here to compete, and the engines and propellers were running at 6700 revolutions. His firm had been able to increase the revolutions in a boat up to 6000.

The Chairman, in closing the meeting, suggested that the author seemed to find difficulty with regard to the expensiveness of tank testing ; but surely the owner should be made to pay the cost of the tank experiments. That concluded the day's proceedings.

(To be continued.)

Internal Combustion Locomotives.*

By Lieut.-Colonel E. KITSON CLARK.

Annihilation of time and space and efficient production of power have been accepted as symptoms and reputed as advantages of Western civilisation. For the last hundred years the steam locomotive has been a prime minister in these services. Its day is not yet over. Where reliability, versatility, and flexibility are required, where loyalty in lonely places is looked for, there will still be the steam locomotive ; but versatility and flexibility are not necessarily partners with rigid economy. A more complete use of Nature's heat units is now called for, together with less human exertion in their application. Under certain circumstances electricity presents the ideal. An electrical machine demands no physical effort from the operator. Its controls are simple, its power supply is not exhausted at speed, but it requires a land overflowing with water and crowded with traffic, and postulates for the region thus richly endowed a *clientèle* as abundant in capital.

Where any member of this trinity is absent, designers in all parts of the world who look beyond the steam engine are turning to the internal combustion engine for the next step in locomotive development. Oil atomised and expanded by combustion is a more economical vehicle of energy than evaporated water ; its machinery—power for power—is less bulky. Its manipulation is a matter of mind rather than muscle and its effort can be maintained at high speeds without exhaustion. So far internal combustion has merit, but in its usual form it is devoid of flexibility and presents great difficulty in starting against a load.

Therefore, when the Still system came before the author he was impressed by its unique combination of internal combustion and steam power ; internal combustion for continuous work, steam for starting, for overload, and for auxiliaries, such as brakes, train heating, &c. The problem has been to obtain a machine of moderate cost with all these qualities and at the same time capable of facing the rough usage of a life on the open road.

The stages in the solution of that problem form the subject of this paper. The fact that they are incomplete will, it is believed, not detract from their interest. A paper before this Institution is often the complete volume of assured success. This is the diary of the journey towards its realisation.

In a few words the Still system is as follows :—The engine is double-acting, with internal combustion at one end of the cylinder and steam at the other end through which the piston rod works. The water in the jacket is in connection with the boiler, and the excess heat from products of combustion assists in the production of steam in the boiler. The boiler is primarily heated by oil burners and the steam generated is used for starting the engine. The two-stroke experimental engine which has been installed for ten years at the Chiswick Laboratory of the Still Engine Company develops 400 indicated horse-power with the expenditure of 0·345 lb. of oil per B.H.P. hour. To obtain such a result on a locomotve would be to save 60 per cent. of the fuel bill, and towards such a result the designs which follow are aimed, but until the final tests with the locomotive are carried out it is not proposed to make any higher claim than a saving of 40 per cent. on the fuel bill alone.

The locomotive to be described has three coupled axles, is designed to undertake the most ordinary regular work on main line service, and its axle load is 17 tons. The outside dimensions of the locomotive conform to the requirements of the great railways of the country. It is calculated to exert a tractive effort of 24,500 lb. from starting to a speed of 6 miles per hour, dropping to 7000 lb. at 45 miles per hour.

Whereas the controversy in marine and stationary practice between the two and four-stroke cycles is not to be decided easily, it is still more complicated in the case of the locomotive which is endowed with special variables of its own. In this case the four-stroke cycle has been selected. For the sake of simplicity in a pioneer machine it was considered preferable to submit to the addition of valves and gear rather than to the vagaries of scavenging air and the cost of its mechanism. Further, although for the same power with the same size of cylinder the two-stroke cycle has but half the number of cylinders of the four-stroke and the former arrangement would therefore certainly cut down the cost, it would also cut down the piston area. Hence, to obtain the necessary steam power at starting in the two-stroke system steam would have to be admitted into the cylinders on the internal combustion side of the piston as well as on the normal steam side. The introduction of steam into the combustion side of a cylinder is indeed perfectly feasible and manageable, but this process would entail such additional gear as would be undesirable in the first locomotive, and the balance of judgment therefore lay in favour of the four-stroke cycle.

The second choice had to be made between a vertical or a horizontal disposition of the cylinders. Vertical cylinders would have to be placed either in line running fore and aft, or in groups across the locomotive. In the first case the transmission of power to the wheels would involve bevel gearing ; in the second, the number of cylinders would be confined to two or three by the exigencies of the loading gauge. It seemed best to avoid the difficulty of each case and adopt horizontality, incidentally gaining space for a longer connecting-rod than a vertical system would allow.

The transmission of force from a reciprocating horizontal engine suspended on springs to the wheels on the rails by means of connecting-rods is as efficient as it is traditional, but the direct use of such rods involves variations in cylinder clearances and also the internal combustion cycle at present introduces high peak forces. It was decided to transmit the impulses in the first instance *viâ* a crank shaft mounted in rigid bearings to rotating gearing protected by a spring and damping device. From this the transmission is by connecting-rods which provide the toleration required by the relative movement between the spring-carried superstructure and the driving wheels (Fig. 2).

The gearing consists of two pinions incorporated in an engine crank shaft. The pinions engage with rims which are applied to a jack shaft through the spring and damping device. At the outer ends of the jack shaft are crank pins which are coupled by rods to the engine wheels. All the mechanism within these pins is concentrated in an enclosed entablature and all the main parts are provided with forced lubrication. The oil is delivered after use from every part into a dust-free crank case or entablature and is subsequently recovered from a sump at the bottom, cooled and re-distributed.

In this concentration the pinions are disposed on the circumference of the crank webs and therefore the lateral space allotted to the crank shaft is entirely devoted to width for the crank webs and surfaces for the bearings. Moreover, the gearing is so much in the middle of everything that it operates in a neutral centre, "a centre of indifference" unaffected by the torsional strains which the connecting-rods put upon its axis. So centralised is it that all working parts which derive from it their activity lie in symmetry about it and the effects of torsional lag are identical in every correlated function.

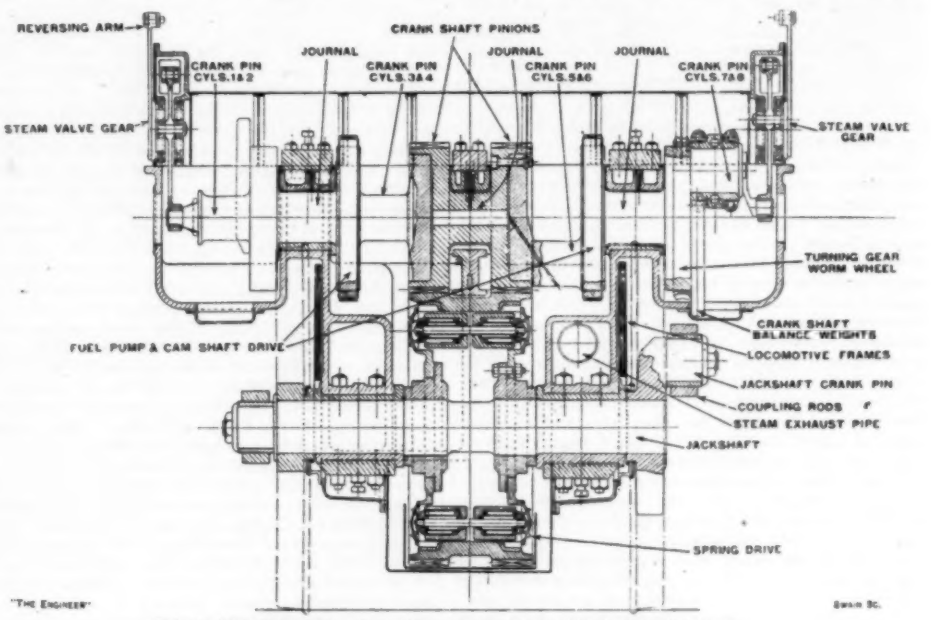


FIG. 2—ARRANGEMENT OF CRANK SHAFT AND JACK SHAFT DRIVE

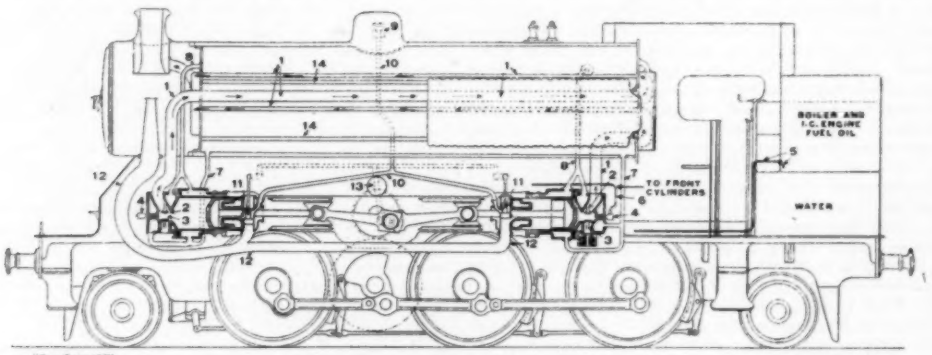


FIG. 1—DIAGRAM OF STILL SYSTEM

Description of Piece.—(1) Internal Combustion Exhaust Passage; (2) I.C. Exhaust Valve; (3) I.C. Air Inlet Valve; (4) I.C. Fuel Oil Valve; (5) I.C. Fuel Oil Pipe (Suction); (6) I.C. Fuel Oil Pipe (Delivery); (7) I.C. Cylinder and Head Cooling Water Inlet; (8) I.C. Cylinder and Head Cooling Water Outlet; (9) Steam Regulator; (10) Steam Inlet Pipe; (11) Steam Piston Valve; (12) Steam Exhaust Pipe; (13) Steam Valve Gear; (14) Fire-box Flue Tubes.

As transmission by gears is adopted and there is no fly-wheel the turning moment must in no instance and at no point involve a negative force. It is only necessary, therefore, to quote the diagrams of comparative turning moment curves given by H. F. P. Purday* in order to recognise that the selection of a four-stroke cycle with gears involves the installation of at least eight cylinders.

Following a consideration of the position of the pinion, of the engine's centre of gravity, of the room that the loading gauge permits to the boiler, of the necessary clearance from the gear case to the rails, a gear ratio of approximately two to one was fixed and a stroke of 15½in. was chosen in view of piston speed and power. Taking this stroke and considering the required horse-power at speed, the bore of the eight cylinders worked out at 13½in.

For the fuel supply to the cylinders airless injection has been adopted. If compressed air had been used, compressors, intercoolers, accessories, and the machinery for operating the fuel valves would have taken up valuable space, and the power thus absorbed would have had to be deducted from the horse-power available for hauling the train.

It was of immediate importance to ascertain the range of flexibility and to find means by which it might be fostered. Hence, having established the principles of the design and determined the limiting dimensions of the main parts, it was decided to build an experimental unit for the purpose of investigating this question on the combustion side. It was necessary to extract from the cylinder its maximum power whether the mechanism was running at 30 or 450 revolutions per minute, and thus to meet the difficult conditions peculiar to locomotive service. The experimental unit was intended not only for this purpose, but for the examination of the quality of combustion, the types of fuel jets, the pump cams and the character and contents of the combustion chamber.

In order to simplify the number of parts to be observed in the course of this comparatively new line of research, and to limit expenditure, the experimental unit was confined to one cylinder and its relative parts ; but as the important end of the range of flexibility to be examined was the beginning, and as experiments were to be made at very slow speeds, a fly-wheel of an apparently disproportionate weight (15 tons) was attached to an extension of the crank shaft. All the details employed were those which would eventually form part of the design of the finished locomotive. A dynamometer was applied to the extension of the shaft, a pedestal bearing being interposed between fly-wheel and drum. The jacket of the cylinder was, on the Still principle, in circulation with the boiler. The boiler itself was of vertical type standing clear of the experimental unit. This was done to facilitate the observation of the working parts. Further, the exhaust gases from the internal combustion cylinder were not—as will be the case in the complete arrangement—passed into the boiler or "heat recovery apparatus," for it was desired that their characteristics might be noted under every condition of speed and power. Neither steam distribution nor the general mechanical details call for comment in this place, as the unit indicated no need for alteration and

* The Institution of Mechanical Engineers.

* "Diesel Engine Design," H. F. P. Purday, page 102.

they come up for description with the complete engine.

One of the advantages of the Still system is that the engine can be run on steam alone at all speeds, thus enabling a general examination of bearings and valve gear to be made during the preliminary "running-in" period. The test unit was therefore run under these conditions for several hours before oil was admitted to the pump. When this was done the engine fired at once quietly and regularly. The compression pressure at low speeds was found to be no more than 230 lb. per square inch. The first jet was drilled with three holes $^{24}/_{1000}$in. diameter at an included cone angle of 19 deg. The jet valve was loaded by spring adjustment to require a minimum injection pressure of 2500 lb. per square inch to open it. The smoke was black at all but the lowest speeds and mean indicated pressures.

Upon increasing the jet-locking pressure to about 5000 lb. per square inch and fitting a nose with larger holes of $^{28}/_{1000}$in. diameter combustion was improved, but at a M.I.P. of 60 lb. or 70 lb. per square inch and at speeds of 200 r.p.m. upwards the smoke was still dark. It was clear that the combination of fuel with air required investigation.

At this juncture attention was directed to the treatise by Drs. Hartridge and Roughton, of Cambridge, who had by experiments established that fluids became fully mingled in a shorter space of time when the ingredients

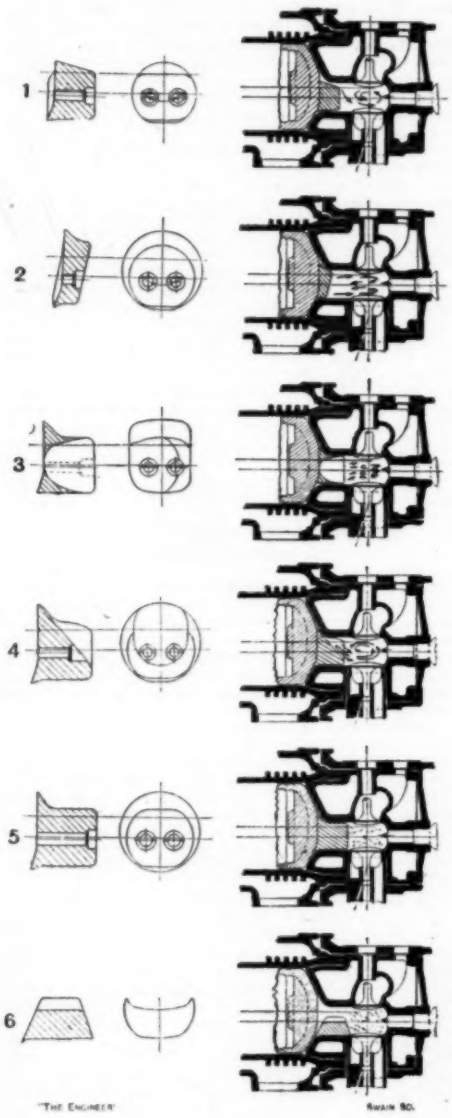


FIG. 3

were confluent rather than contrafluent in their association. It was at once attractive to apply this established observation to certain theories as to the course of the air in compression and at the initial moment of expansion.

In the first place it was clear that the relation of the combustion chamber to the cylinder axis had a potent influence upon the stream lines. The chamber was offset 1½in. below the centre of the cylinder (Fig. 4). This arrangement had arisen from a somewhat exclusive attention to water spaces round the exhaust gas passages in the combustion head. The excentricity provided for the observers an uncontemplated and valuable education, but robbed them of time which was almost more valuable.

Considering then the cylinder and chamber arrangement as first made, it appeared likely that the mass of air in the cylinder which was concentric with the combustion chamber would be deflected from symmetrical movement by the air mass in the crescent of the cylinder section outside the concentric. It may be admitted according to the dictum of higher authorities that currents do not obediently follow the arrows of their would-be masters, the draughtsmen, but a legitimate imagination could not be entirely at fault in visualising some such curling movement. The next step, therefore, was to impregnate this excentric air stream by *confluent* oil particles. The results justified the application of the Hartridge-Roughton theory and a step was thereby advanced in the investigation.

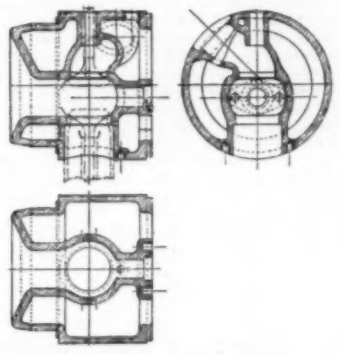
A further stage towards controlling the air movement was made by adding a temporary block of nickel-steel to the piston crown (No. 1 in Fig 3). After trying many jets a M.I.P. of 80 lb. per square inch was obtained with a darkish-grey coloured exhaust. As the result obtained did not appear sufficiently progressive it was decided to try a different block (No. 2), which by reason of its entering edge would produce an effect appropriate to a central spray. The result was 80 lb. per square inch M.I.P. with light grey exhaust. Four other blocks were tried in succession, but with the exception of a large one, No. 5, which gave poor results, the maximum mean indicated pressure obtainable was 80 lb. per square inch with grey exhaust.

It was desired to find what physical effect on the parts was caused by the supposititious block. The engine was therefore run for three hours at the highest mean indicated pressure obtainable with moderate smoke conditions. It was stopped suddenly, the fuel jet was quickly removed and the block observed within thirty seconds of the engine ceasing to fire. It was found to be red hot while the piston crown was black and showed no trace of overheat.

Heavy Diesel oil of 0·95 specific gravity had hitherto been used, but a lighter oil of 0·86 specific gravity was now substituted; an improvement of 5 lb. per square inch mean indicated pressure resulted.

With each type of block a series of different jets was tested, as many as 250 combinations being tried; the size of the holes was changed, also their number and position, until the best jet for a particular block was found. Generally, experience brought out nothing that might lead one to think that the direction of the oil streams inside the cylinder was in any way distorted by the air currents; jets with sufficient penetration to reach the cooler chamber walls, did apparently reach them whatever

1st Combustion Head.



2nd Combustion Head.

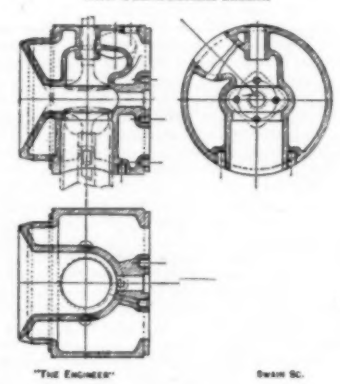


FIG. 4

opposing currents might intervene, and the reverse was also clearly the case because the emission or absence of smoking could invariably be prognosticated. But this deduction did not affect the conviction that it was desirable that air and oil should be allied in confluence.

For each jet a record of the direction of the stream and of the atomisation was obtained in the usual way outside the engine by piercing a paper screen placed at a constant distance from the jet nose.

It was found in general that the higher the compression the less sensitive in some degree was the engine to changes of penetration, distribution or injection timing. With the bigger blocks the engine was quieter, and it is interesting to compare with this the experience of detonation under the earlier conditions. In all cases detonation was more apparent to the ear than noticeable on a diagram, and further, as would be expected with a continuously warm jacket, if detonation took place in any trial it persisted as long as the conditions were unchanged, the principle of the system precluding the relief which is associated with warming up.

Comparing the results obtained by the methods employed up to this point it was at once noticeable how consistent were the top limits of the mean indicated pressures obtainable at speed with each block. This should be the case if the limit of the engine had been reached, but as there was no reason to suppose that the limit of engine power had been reached, attention was directed to the exhaust.

A series of indicator cards was taken with a light spring from the exhaust pipe, in an endeavour to ascertain if any interference was taking place with the suction of pure air at the commencement of the stroke. But this entailed the use of so light a spring that the excessive fluctuations at 400 r.p.m. brought about cards of little value for production.

The fuel pump was the next link in the chain of variables to be investigated. Cams and pump plungers were tested in different combinations, the plungers differing by as much as 35 per cent. in area. The limit of maximum mean indicated pressure at high speed was found to be independent of these variations. The important fact was that the analyses of exhaust gas indicated a shortage of impounded oxygen, and the combination of experiences finally pointed to the need for a change of combustion head.

A new combustion head was therefore drawn out. The combustion chamber was made axial with the cylinder, the valves were increased from 4¼in. to 5in. diameter, and great care was exercised to secure as large water cooling spaces as those in the first design, and the exhaust passages were developed on stream-line principles. As these changes were being developed the opportunity was taken to provide for higher compression by reducing the cubic capacity of the chamber. The modifications in the chamber passages and valves at once produced noteworthy results. Whereas with the previous head a consumption of 0·44 lb. of oil per I.H.P.-hour produced 70 lb. per square inch in M.I.P., whilst the exhaust analysis showed 10 per cent. of free oxygen, under the new conditions the first consumption trial showed an expenditure of 0·36 lb. of oil for 80 lb. per square inch M.I.P., with exhaust analysis of 10 per cent. free oxygen. Arising out of the higher compression the detonation which had been noted before was reduced to an unobjectionable quantity.

(To be continued.)

Exhaust Gas Heat Recovery.

AT a meeting of the Institute of Marine Engineers, held on Tuesday evening, April 12th, Mr. Thomas Clarkson, M. Inst. C.E., read a paper, entitled "The Recovery and Utilisation of Heat from the Exhaust Gases of Internal Combustion Engines." It is pointed out that over 30 per cent. of the heat in the fuel is carried away by the exhaust gases, and that probably more than that percentage of heat is lost in the jacket water. The late Professor Nicholson's experiments demonstrated the importance of gas velocity, and the scrubbing action between heating surfaces and gases emphasised by Professor Parry are referred to as providing a useful starting point for the practical engineer in designing an ideal plant for waste heat recovery.

Boilers which have been used hitherto for waste heat recovery have been of an ordinary type, generally multitubular or sometimes boilers of the Scotch type. It is hardly surprising therefore that the science of waste heat recovery has not made more progress, as it is impossible to obtain the most efficient results from such boilers. The ideal boiler for waste heat recovery should not only fulfil the conditions of impingement of gases on the heating surface, but it should also be entirely immune from expansion troubles. It is important also that the boiler should make an efficient silencer, and render it uncessary to fit any other silencer. When the exhaust gases are not available, as, for example, when a vessel is in port, the boiler should be able to be conveniently heated by an independent oil burner. A waste heat boiler should be of the most robust and fool-proof type. It should work well with the minimum amount of attention, and it should have the lowest cost for maintenance.

A boiler for which it is claimed that it fulfils these ideal conditions is the thimble tube type, which was originally designed to meet the extremely stringent conditions met with in the problem of road transport. The boiler having demonstrated its remarkable properties in this service, it was suggested as the ideal type of boiler for waste heat recovery from the exhaust gases of internal combustion engines. Careful tests were carried out four years ago with a Vickers-Petters engine of the two-stroke type, 84–90 B.H.P. These tests gave very interesting results, and at the same time indicated the necessity for suitable provision being made for decarbonising the heating surface.

In the thimble tube type of boiler, any deposit may be burnt off without straining the tube joints. The method also permits of a differential tube spacing, giving a high gas velocity through the boiler. The boiler may be run in a dry condition without disadvantage, owing to the gas temperature never reaching a point sufficiently high to burn the tubes. The maximum gas temperature may be given as 700 deg. Fah. up to possibly 1000 deg. Fah. A usual figure for a four-stroke cycle engine is 600 deg. to 650 deg. Fah., and about 500 deg. Fah. for a two-stroke cycle engine.

As a general rule, 300 deg. Fah. can be taken as the practical limit beyond which the gases should not be cooled, although there are cases where gases are required to be cooled below this temperature, and in tests conducted by Professor Cook at King's College—described elsewhere in this issue—the gases were reduced in some cases to as low as 143 deg. Fah. The quantity of thermal units recoverable may be readily estimated by the following simple formula:—

$$\frac{\text{B.H.P.} \times C \times D}{4},$$

C being a constant, in the case of four-stroke engines 12, and in the case of two-stroke engines 20; D being the drop in temperature of the gases.

If hot water is to be produced, say, up to a temperature of 200 deg. Fah., the gases can easily be cooled another 100 deg., which, in the case of a two-stroke engine may represent an increase of 100 per cent. in the heat recovered.

One difficulty which is met with by designers of waste heat boilers is the unfortunate fact that there are at the present time no regular standard diameters of exhaust pipes in relation to horse-power. Some makers will use a 7in. exhaust pipe for the same power of engine, for which others will use a 10in. or a 12in. pipe; or, say, a 36in. pipe in place of one of 24in. From the point of view of heat recovery it is always desirable to keep the exhaust pipe as small as possible, consistent, of course, with the avoidance of back pressure.

Back pressure has been regarded as a "bogey" by engine builders, more particularly in reference to engines of the two-stroke type, and it has been difficult to convince engine builders that the application of a properly designed waste heat boiler need not create any back pressure, or in any way impair the thermal efficiency of the engine.

It has been shown by careful tests that application of the thimble tube boiler improves the volumetric efficiency without having any detrimental effect upon the thermal efficiency. In one case it was found that the fuel consumption for a given horse-power was reduced by as much as 3 per cent. after a thimble tube boiler was fitted to the exhaust pipe. Professor Gilbert Cook, of King's College, University of London, has made careful tests—already referred to—on this point, and he has also shown that on the assumption that the temperature of feed water can be taken as a basis, efficiencies as high as 86 per cent. of heat recovery can be obtained. In this connection, reference may be made to tests recently conducted on oil firing of thimble tube boilers, in which efficiencies as high as 91½ per cent. were obtained.

With a properly designed waste heat recovery installation, it is possible to regenerate 5 per cent. of the power of four-stroke engines by employing the best type of waste heat boiler, in combination with a low-pressure turbine. This means that in the case of a vessel of 10,000 S.H.P., about 500 H.P. can be generated from the waste gases, representing a saving of not less than 2 tons of oil per day, which would go far to provide all the power required for the auxiliary services of the vessel, including lighting, steering, ventilation, &c.

Battery Eliminators.

"Battery Eliminators or Appliances for the Operation of Radio Receiving Apparatus by Energy Derived from Electric Supply Mains" was the title of a paper read before the Wireless Section of the Institution of Electrical Engineers by Messrs. Philip R. Coursey and H. Andrews on Wednesday, April 6th. The precise arrangement of apparatus necessary to provide a high-tension supply to a radio receiver depends upon whether the supply system is an alternating or direct-current one, and in the latter case some kind of rectification must, of course, be provided. The current which can be drawn directly from even the best direct-current supply is much too irregular to serve as a supply to a radio receiver, the irregularities arising from commutator ripples and to sparking at the commutators of such machines and at switches, &c. The function of the high-tension supply appliances is to filter and smooth out such irregularities and to deliver to the set an energy supply at the required voltage. The essential

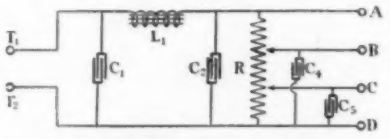


FIG. 1—SIMPLE FILTER CIRCUIT

elements of a high-tension supply appliance suitable for use on a direct-current system is shown in Fig. 1.

Across the input terminals T_1 and T_2 a pair of condensers C_1 and C_2 is shunted, and between these condensers there is a choke coil L_1. The combination acts as a filter to suppress currents of the higher frequencies and to allow the lower frequencies and direct current to pass through. The first condenser C_1 by-passes a proportion of the ripple frequencies for the reactance of the condenser falls for increasing frequencies. The choke coil L_1 offers an impedance to these ripples, and this impedance increases with the frequency, thus allowing only the lower frequencies to pass through to the second condenser C_2, which offers an additional selective action similar to that of the first condenser C_1. The general form of this filter is of the well-known low pass type. Frequently an additional filtering stage consisting of an additional choke coil L_2 and condenser C_3 is added to improve the filtering efficiency, as

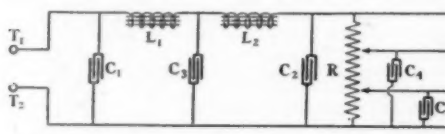


FIG. 2—CIRCUIT WITH ADDITIONAL FILTERING STAGE

shown in Fig. 2. The full voltage across the last or output condenser C_2—Figs. 1 and 2—is obtained from the terminals A and D to which the radio set may be connected. With a 200 to 240-volt supply at least 200 volts are usually available at those output terminals, the difference being the voltage drop due to the resistance of the choke or coils L_1 and L_2. Most radio apparatus, however, requires one or more lower voltages in addition to the full output voltage, and these voltages may be obtained by a potentiometer arrangement R connected across the output terminals A D.

It is usual and desirable to connect additional condensers of at least 1 μF capacity across these additional tapping points, as shown at C_4 and C_5, and these condensers provide a certain measure of additional smoothing action, but their more important action is that of preventing excessive coupling between valves when more than one valve stage is operated from any one tapping point. If the condensers were omitted the varying anode currents drawn by each valve of the radio receiver would be forced to travel through a portion of the resistance R, producing across its terminals a voltage drop of the same frequency, which would in consequence be communicated to the remaining valves in the receiver when low-frequency oscillations or howling of the receiver would be liable to occur. The low impedance offered by the by-pass condensers C_4 and C_5 to the passage of alternating currents effects a considerable diminution of the voltage available for producing such feed-back effects.

For the same reason the capacity of the output condenser C_2 must also be large—a capacity of 2 μF is usually adopted—but larger values are desirable. In lieu of the potentiometer arrangement for tapping the output voltage, the arrangement shown in Fig. 3 may be used, where it will be seen that a series resistance is used between the high-tension positive terminal A and the load applied to the tapping terminals B and C. These series resistances are indicated at R_1 and R_2, one being connected in series with each tapping point B and C. Two by-pass condensers C_4 and C_5 are shown connected in the same way as in Figs. 1 and 2, this scheme being more simple than the potentiometer arrangement. It also offers the additional advantage of somewhat reducing the coupling between different valves in the radio receiver, because the total high-tension current drawn by the valves is subdivided through different resistances.

This results, however, in a somewhat greater voltage variation in the tapping points B and C with changes in

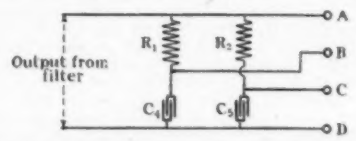


FIG. 3—SERIES RESISTANCE TAPPING SCHEME

the load current drawn by the valves. If the potentiometer arrangement be used on the lines of Figs. 1 and 2 the total resistance R needs to be high, for otherwise it will draw too large a current through the filter. Normally the resistance of the chokes L_1 and L_2 is much in excess of 1000 ohms in order to obtain a large inductance in a small space and at a reasonable cost, so that only a few milliampères can be drawn through the filter without causing excessive voltage drop. For this reason the method shown in Fig. 3 is also advantageous, as it makes a smaller demand upon the filter. Convenient values for the resistance R_1 and R_2 are generally found to be between 10,000 and 100,000 ohms, depending upon the voltage and the current desired at each of the tapping points. A small demand for current will obviously necessitate the use of a higher resistance and any considerable change made in the output requirements will necessarily involve a change being made in the resistance value, unless a considerable change in operating voltage is permissible.

The paper also deals with the design of the high-tension filter, permissible ripple voltages, the rating of high-tension supply appliances, the measurement of output characteristics, the grid bias supply, high-tension rectifier arrangements, low-tension supply appliances, low-tension supply rectifiers, &c.

The Quarter's Shipbuilding Returns.

Great Britain and Ireland.—Lloyd's Register Shipbuilding Returns for the quarter ended March 31st, show that the tonnage under construction in Great Britain and Ireland—1,216,932 tons—was 456,848 tons more than at the end of December, 1926, and about 374,000 tons more than the tonnage being built twelve months ago. The tonnage on which work was suspended at the end of March, 1927, amounted to only 20,083 tons, as compared with 99,468 tons at the end of December, 1926. The totals, although the highest since December, 1924, were still 673,000 tons below the average tonnage being built during the twelve months immediately preceding the war, *i.e.*, 1,890,000 tons. A very large increase was shown in the tonnage commenced during the quarter, namely:—579,839 tons, as compared with 152,404 tons during the fourth quarter of 1926. The tonnage launched during the past quarter—127,747 tons—showed an increase of 59,894 tons, as compared with the figures for the previous three months.

Other Countries.—The total merchant tonnage being built in other countries—1,352,932 tons—was about 180,000 tons more than at the end of December, 1926. The tonnage under construction abroad still exceeds by 136,000 tons the tonnage being built in Great Britain and Ireland. The figures for the leading countries abroad are:—Germany, 350,933 tons; Italy, 208,794 tons; United States, 179,325 tons; France, 154,438 tons; and Holland, 133,645 tons. From one of the tables we learn that 367,026 tons were commenced abroad and 161,048 tons were launched, an increase, as compared with the previous quarter, of 95,789 tons in the tonnage commenced, but the large decrease of 181,375 tons in the tonnage launched.

World.—the total world tonnage under construction—2,569,864 tons—showed the large increase of about 637,000 tons, as compared with the previous quarter, but was still 876,694 tons below the highest pre-war record reached on June 30th, 1913, viz.:—3,446,558 tons. There are at the present time under construction in the world 24 vessels of between 10,000 tons and 20,000 tons each and 11 of 20,000 tons and upwards. Twelve out of the 24, and four of the larger vessels, are being built in Great Britain and Ireland. The total figures include 97 steamers and motorships, each of over 1000 tons, with a total tonnage of 602,846 tons, under construction in the world for the carriage of oil in bulk. Of these tankers, 57 of 342,272 tons are under construction in Great Britain and Ireland, and 8 of 63,370 tons in France.

Motorships.—The tonnage of vessels now being built in the world which are to be fitted with internal combustion engines amounts to 1,172,178 tons, while the tonnage of steam vessels under construction is 1,370,490 tons. The motor tonnage is thus 85½ per cent. of the steam tonnage. The tonnage of motorships being built at the end of March in Great Britain and Ireland—458,337 tons—amounted to 60·7 per cent. of the steam tonnage under construction. In Danzig, Denmark, Holland, Italy and Sweden the motor tonnage under construction greatly exceeds the steam tonnage, the combined totals for those countries being 380,367 tons of motorships and 100,503 tons of steamers. The world figures include 70 motorships each of between 6000 tons and 10,000 tons; 13 of between 10,000 tons and 15,000 tons; 6 of between 15,000 tons and 24,000 tons; and 1 of about 33,000 tons.

Marine Engines.—Another table shows that the total horse-power of the engines being built or being installed on board vessels at the end of March, 1927, amounted to 1,922,217 H.P., of which 881,617 H.P. were being built or were built in Great Britain and Ireland; 252,800 H.P. in Germany; 219,900 H.P. in Italy; 111,655 H.P. in the United States; 105,740 H.P. in France; and 350,505 H.P. in other countries. Excluding 106 engines of less than 500 H.P. each, the average horse-power of each set reaches 3226 H.P.; the average for reciprocating steam engines being 1673 H.P., for oil engines 3797 H.P., and for steam turbines 9195 H.P.

Lloyd's Register Class.—Of the vessels under construction in the world—which total excludes vessels the construction of which has not actually been commenced, and also all vessels of less than 100 tons—372 of 1,779,603 tons are under the inspection of the Society's surveyors, with a view to classification in Lloyd's Register Book.

ELECTRICAL OSMOSIS.

Members of the Junior Institution of Engineers present at the meeting on April 8th listened to an interesting lecture and demonstration by Mr. E. Ambrose, M.I.E.E., on the subject of "Electrical Osmosis." Mr. Ambrose led up to his subject by explaining first of all the meaning of such terms as solution, suspension, diffusion, dialysis, dispersion and peptisation. Dialysis, he said, was the separation of substances by diffusion through a membranous partition; osmosis was closely related to dialysis, and might be defined as "the tendency of fluids to mix or become equally diffused when in contact, even through an intervening membrane or porous structure."

If a diaphragm were placed in a cell so as to divide it into two portions, each portion containing, say, acidulated water, and a current of electricity were passed through the diaphragm, then the liquid in one side of the cell would increase, showing that the water passed through the diaphragm. The side of the cell to which the water passed was the one containing the negative electrode. To that phenomenon was given the name electrical osmosis.

The author said that electrical osmosis was ever present in connection with rubber and fabric-insulated conductors that were carrying direct current, any moisture being driven through to the copper of the negative. The dewatering of substances by electrical osmosis had been tried to a large extent in Germany. There was also a process for extracting sugar from beet, and for dewatering and purifying clays. There seemed to be much scope for the use of electro-osmotic action, as it had been demonstrated that liquids bearing narcotics or drugs could be forced through living skin and membrane by an electric current.

ENGINEERING CONFERENCE AT MANCHESTER.

The Manchester Engineering Council, the President of which is Mr. L. E. Mather, has arranged a week-end Engineering Conference between employers and employees in the industry, to be held at the University, Manchester, on Friday, Saturday and Sunday, April 22nd, 23rd and 24th next. Visitors from all parts of the country are invited to attend. The following programme has been arranged:—

On the Friday at 7 p.m., there will be a reception at the Whitworth Hall by the Lord Mayor of Manchester (Alderman G. H. Swales) and the President of the Council. It will be followed at 7.30 p.m. by a public meeting in the Whitworth Hall, when the subject of "Economic Production" will be discussed, the speakers being (1) Mr. W. L. Hichens (chairman, Cammell Laird and Co., Ltd.), and (2) Mr. W. M. Citrine (general secretary, Trades Union Congress General Council, and Electrical Trades Union).

On the Saturday morning, the Conference will be continued in University Union at 10 a.m., the subject being "Future of the Industry," the leading speakers being Mr. Alexander Ramsay (chairman, Engineering Employers' Association, Birmingham), and Mr. T. Chadwick (chairman, Executive Committee, National Union of Foundry Workers). The subject for discussion in the afternoon is "Arbitration in Industry," which will be introduced in the first instance by Sir Harold Morris, K.C. (President of the Industrial Court), and replied to Mr. J. Kaylor (executive, Amalgamated Engineering Union). The evening meeting will begin at 7 p.m., and the subject chosen is "Aspirations of Trades Unions." The first speaker will be Mr. J. T. Brownlie (President, Amalgamated Engineering Union), and the opener of discussion Sir Holberry Mensforth, K.C.B. (managing director, Bolckow, Vaughan and Co., Ltd.).

On the Sunday the concluding meeting will be held in the University Union at 11 a.m., the subject chosen being "Works Committees." The first speaker on this occasion will be Mr. E. J. Fox (managing director, Stanton Ironworks Company, Ltd.), and the opener of the discussion Mr. S. Ratcliffe (Amalgamated Engineering Union). At 1.15 p.m. Luncheon will be taken in the Refectory, and it will be followed by a "Summing-up of Conference," by the chairman, Mr. L. E. Mather (chairman, Mather and Platt, Ltd.). In the afternoon visitors to the Conference will attend service at 3 p.m. in the Cathedral.

During last year Killarney Junction on the Great Southern Railways of Ireland was remodelled, so that it could be worked from Mallow Station box, under the company's scheme for long-distance point operation by hand-generated electricity. Alterations have also been made at Dunlaoghaire—which means Kingstown and is pronounced Dunleary—and Harcourt-street that will reduce the number of signalmen required. The lines between Clonsilla and Dunboyne and between Oranmore and Galway have been converted from double to single lines, with a view to reducing the cost of upkeep without affecting efficiency.

Railway Matters.

IN our annual article, "Railways in 1926," which appeared in THE ENGINEER of January 14th last, mention was made of the reconstruction of the steel floating inner and outer gates for the Alexandra Dock, Hull, and it was observed that they had been completed but were not then in place. It is now announced that the gates have been brought into use.

THE Timiskaming and Northern Ontario Railway, owned and operated by the Provincial Government, will be extended this season from its present terminus 68 miles North of Cochrane towards its ultimate objective of James Bay. Work will be begun early in May, and while it is not expected that the line will be completed this season, it will be carried a sufficient distance to open up important mineral areas in the James Bay basin and to provide access to power sites on the Abitibi River.

IN this column of our issue of July 16th last mention was made of the intention of the London and North-Eastern Railway Company to divert its Walton-on-the-Naze branch further inland owing to it being imperilled by coast erosion. Formal notice is now given by the company of its intention to apply to the Ministry of Transport for an Order authorising the work. The deviation is to extend from a point 183 yards east of the centre of the level crossing east of Frinton Station to a point 50 yards north-east of the signal-box at Walton-on-the-Naze Station.

THE traffic returns published last week complete the figures for the first quarter for the present year. Unfortunately they do not present a true tale as the last week of the current year compared with Good Friday week of last year, and therefore there were big decreases this year in the passenger receipts and large increases in the goods. Perhaps therefore it were better to say that at the end of the twelfth week the London and North-Eastern had an aggregate increase of £160,000 and the Great Western one of £8000. The London, Midland and Scottish had a decrease of £8000 and the Southern £134,000.

IT has long been the practice on the Great Western and on the Underground system to welcome suggestions from the staff as to what the men think could be done to economise in operation, add to safety and to improve facilities. Such ideas are considered by a committee and suitably dealt with by being accepted, put aside for development or modification or by being rejected. Monetary or other rewards are granted for the suggestions that commend themselves, and publicity is given to the successful ideas and their promoters. One of the new departures made by the new administration on the London, Midland and Scottish Railway is the creation of a similar suggestion bureau at Euston.

Two locomotive items of interest were mentioned by Mr. Whitelaw at the recent annual meeting of the London and North-Eastern Railway. One was, on the subject of the upkeep of rolling stock during the coal stoppage, that so far as the locomotives were concerned, the company would speedily overtake the arrears owing to a purchase recently made from the Disposals Board. Those engines were of their own type and, after reconditioning, would be practically new locomotives. The other remark was in reply to Lord Monkswell's inquiry as to what work there was on the line for the fifty-seven "Pacific" type locomotives to do, and, as far as he knew, there were hardly more than half-a-dozen trains that could not, quite easily, be worked by the much smaller "Atlantic" and six-coupled machines, which cost, he imagined, quite £2000 apiece less to build. Mr. Whitelaw, in reply, said that he was absolutely satisfied that the "Pacifics" were doing admirable work, and that they had heaps of work for them to do. There was an opportunity, he thought, for them to be able, profitably, to extend their use in Scotland, and the question was being looked into.

BRITISH railway companies are handicapped, particularly as compared with American practice, by the smallness of their goods consignments. That condition is being aggravated by the number of small consignments being yearly on the increase. Thus, on the London, Midland and Scottish there were, in 1923, 347 consignments per 100 tons; in 1924 the number was 353; in 1925 it was 364; and 368 in 1926. Actually, last year, despite its lamentable bad trade, there were 100,000,000 consignments averaging between 5 cwt. and 6 cwt. We would add that, in our opinion, the very success of the railway companies has, in this respect, been their own undoing. Tradesmen no longer keep the amount of stock they did. A tailor, for instance, has his samples only, and when a suit is ordered it is sufficient to telegraph or telephone the wholesale house for the required length of cloth, which the railway company delivers the next morning. In another respect has this success been, in a sense, fatal. In order to give prompt dispatch and delivery, wagons are frequently sent away without a full load; were they kept back—as a State-owned railway would probably keep them—to get a full load, the consignments would be delayed.

A COLLISION between a train and a Wolseley motor car on November 15th last at Frost-lane level crossing on the Fawley–Hythe light railway of the Southern Railway had no serious personal results. But it was of interest, inasmuch as the crossing is not protected by gates or watched by a gatekeeper To protect the railway from the road there is a cable guard on each side and two warning boards are erected by the side of the road on both the western and eastern approach. Combined whistle and speed boards are fixed about 200 yards along the railway from the crossing in each direction. Lieut.-Colonel Mount inquired into the accident and reported that it happened in broad daylight, and was the outcome of the untimely failure on the part of the occupant of the motor car, when approaching the crossing, to exercise requisite caution in respect not only of observance of the road, but of the warning notices. That was evidently the result of excessive speed, unjustifiable at the time and in itself indicative of error of judgment, having regard to the prevailing weather conditions, which necessitated the use of hood and side screens, admittedly restricting vision, and, in Colonel Mount's opinion, tending also to prevent the sound of the whistle from the train being heard.

Notes and Memoranda.

THE year 1927 should be one of great development in the mining industry of Quebec and Northern Ontario. Gold production for the Porcupine and Kirkland Lake districts was over 30,000,000 dollars during last year, and, with extensive additions to the milling plants in both Porcupine and Kirkland Lake well under way, 1927 should prove to be the best year so far in gold production.

IT is stated that vanadium metal has been prepared by J. W. Marden and M. N. Rich in the Research Laboratory of the Westinghouse Lamp Company, Bloomfield, N.J. Contrary to previous statements in the literature, this metal is not, says the *Chemical Trades Review*, like arsenic or bismuth. It is not brittle, but may be cold worked into wire or other forms. In properties vanadium resembles tantalum.

IN a letter to *Nature*, April 2nd, Dr. F. W. Aston, of Cambridge, states: "It will doubtless be a surprise to many, as it was to me, to hear that the element mercury is obtained in the distillation of coal tar. This fact was recently brought to my notice by Mr. W. Kirby, of the South Metropolitan Gas Company, who kindly provided me with a sample for examination of its isotropic constitution. He informs me that the mercury appears in the lightest of the fractions distilled and occurs to the extent of about one part in seven millions of undistilled tar. Its accumulation in any reasonable quantity will therefore take place only in a plant arranged for continuous fractionation."

THAT Japan ultimately may sink or slip over the edge of the Tuscarora Deep and disappear into the Pacific, is the opinion of Dr. L. F. Noble of Los Angeles, who attended the Pan-Pacific Science Conference held at Tokyo in November last. Dr. Noble is not very precise as to the date when the Japanes Noah will have to build the Ark, but he thinks that such a disaster may occur within the next hundred thousand years. At any rate, he adds, that if the periodic earthquakes continue, there is reason to believe that Japan at some remote day will pass from the face of the earth. The bottom of Sagami Bay at Yokohama sank from 200ft. to 1000ft. as a result of the last earthquake, and another such tremour might start a slide that would carry Fujiyama down into the abyss and leave only its cone sticking above water.

AN account of a rather unusual crane accident is given in a recent issue of *Vulcan*. The crane, of 5 tons capacity, was being used to unload timber from barges alongside to a wharf above, by means of chain slings, in loads of about 15 cwt. each. In this process the sling chain was unhooked at one end and dragged from under the timber by means of the crane hook, and the crane then slewed round for a fresh load. At this point the slewing motion appears to have been suddenly reversed for some purpose. Coincident with this, one of the teeth in the slewing race wheel broke and jammed, thus suddenly arresting the motion of the jib, with the result that the whole momentum of the jib was thrown on to the crane truck, and two of the truck wheels were thrown off the rails, causing the crane to heel over, owing to the preponderance of the back balance over the unloaded jib, and to fall on to the barge below.

A REPORT on the methods of analysis of coal has just been published for the Department of Scientific and Industrial Research by H.M. Stationery Office (price 9d. net). It is the seventh of the series of reports on matters connected with the Physical and Chemical Survey of the National Coal Resources, and supersedes Survey Paper No. 2, "Interim Report on Methods of Analysis of Coal." The report has been prepared by the Sampling and Analysis of Coal Committee of the Fuel Research Board, and the methods described have been adopted by the Department of Scientific and Industrial Research for the purposes of its work on coal. The methods recommended are the result of extensive investigations carried out by the members of the Committee in their own laboratories. A number of changes have been made in the methods given in the interim report mentioned above, and these have been incorporated in the revised report, which is now published for general information.

SPEAKING at a recent meeting of the South Wales Institute of Engineers, Professor G. Knox said that many of the buildings in the South Wales valleys had been erected on a "mantle" of loose *débris* brought down by previous soil creeps and landslides, and those mantles were liable to further movement if the water drainage was obstructed, or where cuttings had been made into them for other purposes. When a landslide took place in South Wales in the vicinity of a colliery tip, the latter, according to the lay mind, was invariably supposed to be the cause of the slide. But that was an erroneous impression, because the weight of a colliery tip had nothing whatever to do with initiating such a landslide. If the land on which the tip was placed was sufficiently stable to hold the tip when it was placed there, no amount of added weight would cause it to become unstable. The additional downhill pressure, due to the weight of the tip, would be counterbalanced by the additional friction resulting from it.

SOME tests carried out by the American Wood Preservers' Association show that (1) incising or slitting the faces of timbers to permit a more uniform penetration of creosote or preservative, affects the strength of Douglas fir beams in bending only slightly; a loss in fibre stress at elastic limit, modulus of rupture and horizontal shear being a trifle over 2 per cent. (2) The combined effect of incising and treating may reduce the fibre stress at elastic limit slightly more than 10 per cent., while in modulus of rupture and horizontal shear the reduction is less than 7 per cent. (3) Incising caused Douglas fir to absorb 43·46 per cent. more creosote than timbers not incised, when treated under identical conditions. (4) To illustrate that a reduction in modulus of rupture of less than 7 per cent. does not materially influence the safe working stress in timber design, curves show that treated timbers have an average of 1288 lb. per square inch greater strength than the untreated timbers for a period of slightly more than forty-five years. (5) Seasoning Douglas fir by boiling under a vacuum does not weaken the timber to any further extent than does such air seasoning as occurs in usual practice.

Miscellanea.

WORK is to be started immediately on the dredging and improvement of Beira Harbour, East Africa.

A BRICK factory is to be erected at East Beauport, Quebec, at a cost of some 1,000,000 dollars.

THE District of Hull, Quebec, has available more than 160,000 H.P. of electric energy and plenty for any industrial concern which may desire to establish itself there.

IT is proposed that a bridge should be built across San Pablo Bay, California, at a cost of 12,000,000 dollars. It would be 14,600ft. long, with a carriage way of 30ft., and a clearance for shipping of 135ft.

BY the close of the present year plants with a capacity of over a quarter of a million horse-power of hydro-electric energy will be installed on the Winnipeg River, Manitoba. When the river is fully developed about three times this amount of power will be available.

IT is shown by the preliminary figures of the Census of Production for 1924 that the output of cement in Great Britain during that year amounted to 3,143,000 tons, valued at £6,705,000, compared with 2,877,000 tons, valued at £3,439,000 in 1907, when the previous Census was taken.

IT is announced that the Carnegie Steel Company, of America, has put down a new rolling mill, by means of which joists with parallel flanges, in contradistinction to the normal joist with tapered flanges, may be rolled. These joists are rolled in depths ranging from 8in. to 30in. and widths from 6in. to 16in.

ARRANGEMENTS are being made for the construction of a second tunnel aqueduct to carry water from the Catskills to New York. It will be over 20 miles long and cut in rock at a depth of about 500ft. The carrying capacity is put at 700 million gallons a day. The existing tunnel has a capacity of 500 million gallons a day.

ACCORDING to the *Iron and Coal Trades Review*, the Daido Electric Steel Works, Ltd., Nagoya, Japan, claims to have succeeded in making manganese-steel railway crossings, and will endeavour to manufacture them in large quantities in order to reduce the importation of such crossings and enable even Japan to export them to Korea and Manchuria.

THE Manitoba Government has laid out an extensive programme of highway construction and improvement, involving an expenditure of approximately $2,000,000. New roads having a total length of 141 miles will be constructed at a cost of about $456,500, and 325 miles of roads now in bad condition will be surfaced with gravel at a cost of $682,739. Large grants will be made to municipalities for local road work, and surveys will be made on the route of the Trans-Canada Highway, the Manitoba section of which will cost at least $250,000.

A MESSAGE from Moscow states that owing to the revival in the shipbuilding industry the Soviet Shipbuilding Trust is to make important extensions to its yards. Before the end of this year it will, it is announced, be possible to build vessels 120 m. long at the North Shipbuilding Yard. The subsidiary works are also to be extended, and a wood manufacturing factory erected. Extensions will also be made at the other yards—the Baltic and the Martz Exchange. A total sum of over 3,000,000 roubles is to be employed for these purposes by the Shipbuilding Trust.

THE number of furnaces in blast in this country at the end of March was 178, a net increase of 12 since the beginning of the month. At the end of April, 1926, 147 furnaces were in blast, and at the end of March, 1926, 151. The production of pig iron in March amounted to 671,800 tons, compared with 571,100 tons in February and 568,500 tons in March, 1926. The production includes 229,800 tons of hematite, 221,400 tons of basic, 167,700 tons of foundry, and 21,200 tons of forge pig iron. The production of steel ingots and castings in March amounted to 949,600 tons, compared with 826,800 tons in February and 784,100 tons in March, 1926.

A COMMISSION to inquire into the economic practicability of generating power at central power plants and at water power sites, and of distributing the same throughout the Province, has been appointed by the Government of Saskatchewan. It will consist of Mr. L. A. Thornton, Regina (chairman); Mr. Arthur Hitchcock, Moose Jaw; and Professor A. R. Greig, of Saskatoon; with Mr. R. N. Blackburn, chief mechanical superintendent of the Province, as secretary. The Commission will report on the advisability of a central power station or several plants in various parts of the Province; the probable cost of the alternative systems; the capacity of existing plants; electrification of farms; municipal systems and the question of authorising them to sell power beyond their limits; the present market for power capable of being produced; and whether the installation of plants would create a demand for such power.

THE Lenham By-pass, a concrete road a mile and a quarter in length, was officially opened on Tuesday last. The road, which lies half way between Maidstone and Ashford, constitutes part of the improvements carried out on the London–Folkestone road. The entire scheme, which has cost £320,000, of which the Ministry of Health has paid 75 per cent., was embarked upon to relieve London unemployed, and about 1000 men, drawn from local labour exchanges, have been provided with employment during the last two years. The total length of the road which has been undergoing reconstruction is approximately 12 miles, and the work has included the construction of the Lenham By-pass, the Harrietsham By-pass and the Northern and Southern By-passes at Charing, all of which are of unsurfaced concrete. The road for the remainder of its length has been widened so as to provide a carriageway 30ft. in width, while the gradients and corners have been eased so as to reduce the risk of accidents. In widening the road, the system adopted has been to lay concrete haunches on either side and then re-surface the whole area with a special bituminous compound. The concrete haunches have not only given additional width, but have considerably strengthened the old consolidated central portion. Concrete kerbs are laid along the entire length on both sides.

NEW SWITCHGEAR WORKS OF THE OERLIKON COMPANY

(*For description see page* 404)

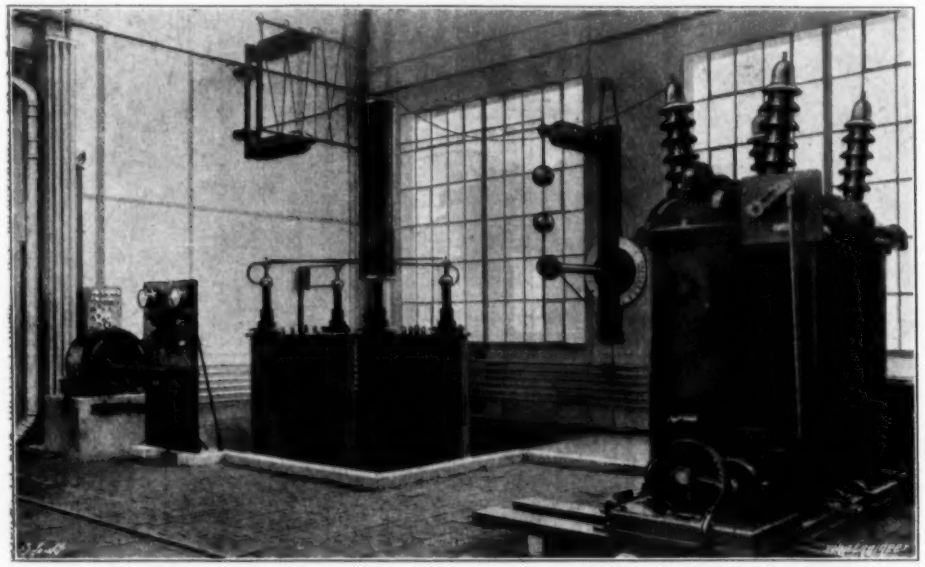


FIG. 4—PART OF TEST ROOM ON GROUND FLOOR FOR LARGE APPARATUS

FIG. 5—TEST ROOM FOR APPARATUS ON SECOND FLOOR

FIG. 6—PART OF TEST ROOM ON SECOND FLOOR

FIG. 7—PART OF ERECTING SHOP

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Half-yearly (including index number) .. £1 12s. 6d.
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THE ENGINEER.

APRIL 15, 1927.

America and Great Britain.

The phenomenal prosperity of the United States at the present time has aroused the curiosity and envy of other nations, and, owing no doubt to the ties of kinship, of Great Britain in particular. Private investigators have reported upon the conditions which prevail in Am rica, commissions have gone thither to discover the reasons of that prosperity, and authors in books and in the Press have fulminated against the British system, have held up the system of the United States as a pattern to be followed, and implored Great Britain to "Americanise" itself. To be frank, we believe that engineers have heard already enough of these damaging comparisons, and that they will join with us in hoping that the report of the delegation appointed to study industrial conditions in Canada and the United States of America, which was published recently, may be the last of such productions. Indeed, there is no good reason why it should not be, for it is clear that the field of inquiry has been exhausted, and that no new facts can be adduced. There is nothing whatever in this report that has not been said before, and it neither adds anything to our knowledge of why America is so prosperous at the present moment nor tells us anything new about what this country may do to emulate that prosperity. But in one respect it is better than those which have preceded it, for it does seem to recognise more fully than others that American conditions are so dissimilar from British conditions that comparisons have little weight. "Each industrial country," it says, "has difficulties, as well as opportunities for advancement, peculiar to itself, and no one will assume that methods which are practicable in one country are necessarily suited to another." Unfortunately, many people have made just that foolish assumption, and have launched diatribes against Great Britain because she is not as America is.

The members of the small delegation which has presented this report represented employers, employees and the Ministry of Labour, and their chairman was a lawyer interested in industrial questions—Sir William Mackenzie, K.C. They spent three months in the United States and Canada, and seem to have taken some pains to see small works as well as great. Their report is divided into five parts, four of which are devoted to the United States and one to Canada. Several useful appendices are added. From the constitution of the Committee it was to be anticipated that all the members would not see all facts from quite the same standpoint, and we seem to recognise here and there evidences of a compromise in the endeavour to reach a unanimous conclusion. But in one respect at least they do appear to have been in complete harmony. We have already alluded to their recognition of the differences between the conditions which prevail in the two countries; the point is of such importance that we make no apology for returning to it, and quoting another passage which bears upon it. This passage opens that section of the report which deals with Industrial Conditions in the United States: "Industrial conditions and the relations between workpeople and their employers in the North American Continent or in any country can be fully appreciated only if they are considered in conjunction with *the general background of the corporate life of the nation.* That background is created out of a combination of factors—physical, historical, economic and racial. These factors are so different in North America from those to which we in Great Britain are accustomed, that although they have operated on people having similar characteristics and motives, the resulting position is in many respects dissimilar." The words which we have italicised give us the key to the position. It has too frequently been overlooked. In all probability it is quite impossible for observers who spend but a few weeks in the country to form a true conception of "the general background of the corporate life of the nation." Rather do they project what they do see upon the "background" of their own nation. Not having the time to study the differences in habits and in thoughts of the strange land, they assume—sub-consciously perhaps—that they are the same as those to which they are accustomed. Being mistaken in that, their attempt to apply their discoveries are doomed to failure. We have seen Americans themselves make the same mistake. Full of their own systems, they have come to this country convinced that they can transplant them to our soil. It is common knowledge that they have consistently failed. When what is regarded—quite mistakenly—as the American system succeeds in this country, it is when a British firm conversant with every feature of the British "background" takes it up and applies it to the home conditions. The obvious fundamental differences between the two countries are their relative sizes, the density of population, and the opportunities for trade, but behind those facts upon which any statistician may compile figures, there lies an inherent difference in the minds of the people and their attitude towards their surroundings. That difference it is almost impossible to define; it is based upon what is called the "genius of the race," an elusive quality of overmastering power which can no more be defied than gravity, and which can only be modified with great slowness. It is probable that the people of this country, owing to their centuries of contact with other nations, find it easier than others to appreciate the finer side of natural differences, and it is the more remarkable that so many English writers have assumed that American methods can be freely and successfully imported into this country. We are glad indeed that the authors of this report have laid stress upon a fact which has always appeared to us as of the greatest significance.

It would, however, be as wrong to suppose that we can gain no advantage from the study of American methods as to assert that we can lift them from their natural habitat and see them thrive upon our uncongenial soil. Much indeed we may learn, but we may remain certain that it is not until those methods have been moulded and shaped into conformity with the conditions which prevail here that they will be of value to us. Furthermore, it must be remembered that in all these years we have not stood still. Whilst America has been advancing, Europe has been advancing too, and it is far more the conditions which have given recently to the United States opportunities for vast expansion than that they are fundamentally more progressive than Great Britain or Germany. What those conditions are has already been expounded many times, and is again set forth in this report. That we can ever assimilate ourselves to them is highly improbable. It is far more likely that in the course of time—two or three centuries perhaps—America will find herself reaching a position equivalent to that which we have now reached, and that she will then have to suffer comparisons with some new nation given by Providence vast possibilities, unhampered by a long tradition, uncontrolled by a fixed "genius," and free from that resistance to rapid changes which is the constant and natural accompaniment of age.

Internal Combustion Locomotives.

We feel sure that those who were present at the Institution of Mechanical Engineers on Friday evening last will agree that the able paper presented for discussion by Lt.-Colonel Kitson Clark provided not only a subject of first importance for considera-

tion, but also a literary treat. The author took a bold step when he described a locomotive not yet built, let alone tried, which has been designed to work on a principle never before tested under conditions which are, by common consent, the hardest placed before any prime mover. As Mr. H. N. Gresley rightly said, great risk was occasioned by so doing, because failure would mean that the author's name would always be coupled with the results obtained. As to the Kitson-Still engine itself, we feel that certain of its details are to some extent open to question. Granted that the internal combustion engine, with its admittedly high thermal efficiency, presents an attractive proposition, its application to railway work, at any rate of a general character, is beset with many difficulties. The great problem to be solved is the transmission. Herein lies the crux of the whole question as it concerns the mechanical man, and we still await a complete solution of this part of the problem, for it is there, and there alone, that the great dividing line exists between our old friend the steam locomotive and its rival. The internal combustion locomotive can never hope to do effective battle with the other until that gulf is bridged.

Many people are working on this question, and already much has been done. Electrical, mechanical and hydraulic means are at our disposal, and it would appear, so far, that the electrical method leads, at any rate when the high powers demanded in main line service are taken into account. For moderate powers the hydraulic gear has been tried, and with some success, but so far locomotives using it are only of modest proportions. They are useful for shunting or light duties, but would be incapable of dealing with main line traffic. So far as electrical transmission is concerned, the Lomonossoff locomotive is noteworthy on this side of the Atlantic; but the locomotives of the Canadian National Railways fitted with Beardmore engines are at present the most widely used, and the construction of one which will develop 3000 H.P. is well in hand. Whilst designers are working on the development of the application of the Diesel engine to locomotives, others at the same time are seeking to improve the steam locomotive, and not only are engines of what we may term the usual type, embodying improvements which augment efficiency being built, but others having turbines, such as the Reid-MacLeod and the Ljungström, are being put forward. Both in the United States and Germany, much has been done to improve the ordinary type of locomotive, and quite recently we have seen reports on the performance of a new three-cylinder compound locomotive working at 350 lb. pressure and built by Baldwins. On the test plant at Altoona this engine developed a maximum of 4500 I.H.P., and at all rates of working between that and 1500 I.H.P. the water per I.H.P. ranged between 14·2 lb. and 16·6 lb.—a most satisfactory performance. In road service the average fuel rate for three trips of 132 miles each against a ruling gradient of one in 333, and with loads averaging 6241 tons worked out at 41 lb. per 1000 gross ton-miles. On one run with 6589 tons that figure was as low as 39 lb. per 1000 gross ton-miles. The remarkable figures just quoted show that the steam locomotive is still susceptible of improvements. They exemplify, moreover, the common experience that whenever a new competitor appears in the field those already established make every effort to retain their position, and under the new impetus often achieve results which could hardly have been anticipated. But whilst much has been accomplished with the steam locomotive towards improving its economic performance, the internal combustion engine can still show a higher thermal efficiency. The chief obstacle to its further development is its very high cost. That will, no doubt, be reduced in course of time, and is already counterbalanced in a large measure by the economy in fuel which is secured, and—a matter in many cases of great importance—its relative indifference to the qual ty of water which it employs and the reduced quantity that it consumes. These facts are of such importance that we fully expect to see the internal combustion locomotive take an important place in the railways of the world, and we rejoice that the problems presented are being energetically attacked by at least two British firms.

Speaking in the discussion at the Institution of Mechanical Engineers on Friday evening, Mr. Clayton commented rather severely upon a leading article which appeared in our issue of March 4th, and went so far as to suggest that we were not adequately informed. It is scarcely necessary for us to rebut that charge, but we desire to say that our columns have always been open to Mr. Clayton had he been in a position to prove that our statements were inaccurate or incomplete. Moreover, his remark in the discussion that the existence of the Kitson-Still design showed our lack of acquaintance with the facts is hardly to the point, as the substance of the leading article in question was the presence of too many foreign inventions on *steam* locomotives; but it did animadvert, we admit, on the little interest which British railway companies—not the engineers, but the companies—have shown in the internal combustion locomotive. Indeed, with that type, as with developments of other radically new types of locomotives, it is to the private locomotive builders that we have to look, for the companies do not appear to be ready to give that sympathy and financial help which might reasonably be expected from them. In view of all that may be anticipated from success, not only in the direction of economy on home railways, but also in the development of overseas trade, we feel that the railway companies would do a real service to their country by ordering locomotives of hopeful new types for experiment and by giving financial encouragement to research in that direction.

Institution of Mechanical Engineers.

Any paper dealing, however remotely, with the railway locomotive always attracts a large audience and produces a good discussion at the Institution of Mechanical Engineers. Last Friday night's meeting, when Lieut.-Colonel E. Kitson Clark presented his paper, entitled "Internal Combustion Locomotives," maintained the tradition. The occasion was described by one speaker as historic on the ground that in years to come it would be looked back upon as marking the birth of the internal combustion locomotive for general use in this country. Whatever views others may have held on that point, it can be recorded that many leading authorities in the locomotive world showed their appreciation of the importance and interest of the occasion by attending the meeting, although time did not permit them all to contribute to the spoken discussion. We begin a slightly abridged reprint of the paper elsewhere in this issue.

Sir Holberry Mensforth was called upon to open the discussion. He remarked that some of the experimental ground gone over by the author and his colleagues had already been traversed by others. For example, the value of the spherical combustion chamber had already been proved by Ricardo. He thought great difficulty would be found in the Kitson-Still engine in holding the pressure in the cylinders for any length of time. Experience showed that in internal combustion engines the pressure could only be held if the piston speed was fairly high. Referring to the author's opening remarks, he said that he was not aware that electricity claimed to be anything more than a means of transmission, and therefore he was of opinion that internal combustion locomotives with electrical transmission might be found satisfactory in a land which was not overflowing with either water or money. Dealing with the Kitson-Still test unit, he asked whether the 15-ton fly-wheel with which it was equipped was coupled up to the crank shaft. His own experience with alternators driven by eight-cylinder internal combustion engines taught him to expect that without a fly-wheel the impulses would result in the transmission gearing being broken. Did the author, he asked in conclusion, anticipate any trouble as a result of the internal combustion exhaust gases being passed into the boiler, and, as a consequence of their contact with steam, the formation of deleterious sulphur compounds?

Mr. J. D. Twinberrow argued that the apparent simplicity and beauty of the transmission system devised for the Kitson-Still locomotive contained the promise of a whole pack of troubles. The jack shaft arrangement looked very simple and attractive, but in electric locomotive design it had been found very troublesome. There was a reversal of torsion in the jack shaft four times per revolution, and the varying axial load on the jack shaft brasses would give rise to breakages, unless extreme accuracy of workmanship was secured.

Dr. H. S. Hele Shaw maintained that the title of the paper was wrong. It should have been called "The Kitson-Still Locomotive," for it passed over practically in silence the thirty or forty other types of internal combustion locomotive on which work was proceeding to-day.

Captain H. P. M. Beames, London, Midland and Scottish Railway, Crewe, said that in 1920 his company had been very interested in the Still principle as applied to locomotives, but financial and other reasons prevented practical developments being put in hand. All locomotive engineers were desirous of getting away from the well-known difficulties involved in the manufacture and repair of boilers, and it was one of the attractive features of the Kitson-Still design that it pointed the way to the partial attainment of that object. He foresaw the possibility of trouble originating from the rise and fall of the engine on the wheels as a result of the jack shaft being fixed to the frame, and therefore of its partaking of that motion. He thought, too, that trouble would be encountered in getting at the engine parts for inspection or repair. Would it be necessary, he asked, to lift the boiler to get at the big and little ends of the connecting-rods and to examine the jack shaft? The boiler provided seemed extraordinarily small for the work it had to do. The author, in his view, was optimistic regarding the amount of heat he was going to recover from the exhaust gases and jacket water. At Crewe there was a Diesel engine plant of 1200 B.H.P. coupled to a locomotive type of waste heat boiler. The greatest evaporation that could be obtained was 429 lb. of water per hour at 80 lb. pressure. Concluding, he remarked that most locomotive engineers would, with himself, hold the view that oil fuel was not a commercial proposition on locomotives.

Mr. F. H. Livens stated that in the internal combustion part of the Kitson-Still locomotive many of the details were already familiar to internal combustion engineers. The block attached to the end of the piston was, for instance, a very old device. He himself had used it with the object of reducing the clearance volume and increasing the compression pressure. He had come to the conclusion that the most important function of a suitably shaped block was to give a definite lead to the incoming gases to go to one side or the other of the cylinder. He believed that the effect of such lead should replace theories of turbulence. What was required was order, not disorder. He was struck by the very low compression pressure used in the Kitson-Still engine. No doubt existed in his mind that the author was correct in assigning considerable virtue to the fact that the cylinder liner was maintained at a much higher temperature, in the neighbourhood probably of 360 deg. Fah., than was customary in internal combustion engines. No ordinary oil engine could work with such a temperature, but in the Still engine the presence of steam in the front end of the cylinder seemed to make it possible to run satisfactorily with a very high liner temperature. It would be difficult, he thought, to train drivers to operate to full advantage both the steam and the internal combustion side of the engine, and some of the savings secured would probably vanish in the extra care required in looking after the machine. If a 15-ton fly-wheel was really necessary in the case of the single-cylinder test unit, it did not seem to him practicable to run the completed eight-cylinder engine with substantially no fly-wheel at all.

Mr. H. N. Gresley expressed his admiration of the author's courage in undertaking the production of the engine and in presenting a paper on it before the work was completed. It was interesting to note that in order to obtain a constant thrust the internal combustion locomotive required eight cylinders to do what the steam locomotive could do with but two. Continuing Captain Beames' remarks regarding accessibility, he pointed out that the jacketing of the cylinders and cylinder heads with high-temperature water would cause scale to be thrown down much more rapidly than in an engine jacketed with cold water in the ordinary way. It was therefore essential that the jackets should be arranged to be very easily washed out and scaled.

Mr. A. E. L. Chorlton thought, like others, that the author could have saved himself much trouble by taking advantage of previous experience. The use of a combustion chamber connected to the cylinder by means of a neck would, as it should be, always be associated with the name of the late Mr. Akroyd Stuart. He disagreed, however, with Mr. Livens over the question of turbulence. Turbulence, he maintained, was the real factor controlling the rate of burning in the engine. The effect of turbulence diminished rapidly as the speed fell. The virtue of the Still system lay in the fact that that diminution was compensated for and that the engine could be run satisfactorily over a wide range of speed. There was no reason, he maintained, why the author's estimate of the saving to be obtained by the Kitson-Still locomotive should not be realised. The oil engine used one-eighth the weight of fuel consumed by a coal-fired engine of the same power, and consequently had to carry and transport a proportionately less weight of fuel for equal journeys. Even if the cost of oil fuel were four times as high as that of coal, the oil engine would show a gain of 50 per cent. in the fuel bill. The Canadian internal combustion locomotives recently supplied by his firm had now satisfactorily completed half a million miles of running and a double-engined oil-electric locomotive, with a total horse-power of 3000, was now under construction.

Mr. James Brown, of Messrs. Scott's, of Greenock, the builders of the Scott-Still-engined vessel Dolius, said that that vessel had now been in existence for nearly three years, during which time she had run about 150,000 miles. On her last trip she had completed a voyage of about 45,000 miles. He hoped the Kitson-Still locomotive would meet with an equal measure of success. The conditions were, however, entirely different. On board a ship a hundred engine movements might have to be made in the course of

three minutes, to be followed by a run of thirty days without a stop.

Mr. James Clayton expressed disagreement with the views advanced in a leading article which appeared in our issue of March 4th, dealing with the British locomotive and foreign inventors. Continuing, he said that he had seen the Kitson-Still experimental unit, and was astonished by the extreme flexibility secured by means of the dual system. He was pleased also to note that the question of accessibility had been carefully considered, and he thought that there should be no trouble on that score. The fact that in the completed engine the centre of gravity was about 12in. higher than in the average British locomotive was, however, a point for criticism, particularly when high speeds were involved. He also criticised the reduced effect on the internal combustion side resulting from the use of a closed exhaust. In order that steam power might always be available for starting purposes or to assist the engine at banks, it would appear to be necessary to maintain a head of steam at all times in the boiler. For that purpose, was it intended to fit a blower or a fan or some similar contrivance?

Lieut.-Colonel Kitson Clark, in the course of a brief reply to the discussion, said that several of the speakers had attacked him for not taking advantage of previous experience. He had noticed, however, that among those who so criticised him, there was a wide divergence of view as to the interpretation of that experience. He thought every British engineer ought to have the courage to take up a problem, to make his own mistakes, and to find his own way out. On the question of accessibility, he remarked that an entirely enclosed engine could not be very accessible, but at the same time such an engine would require less frequent examination than an open one. He readily admitted that the connection between the jack shaft and the driving wheels was the most important point in the detailed design of the engine.

Obituary.

LIEUT.-COL. PATRICK WALTER D'ALTON.

IT is with great regret that we have to record the death on April 10th of Lieut.-Colonel Patrick Walter d'Alton. Colonel d'Alton was an engineer of wide experience, and was well known in the three chief branches of the profession—civil, mechanical and electrical. He was born in 1856, and was the son of Walter P. d'Alton, M.D. He was educated at Dublin, and received his technical training at the North-Eastern Marine Engine Works at Sunderland and at Hawthorn and Company's works, St. Peters-on-Tyne. His early career was in this way given a bent towards marine engineering and the sea, and for a time he continued to follow in that direction. In 1884 he took his chief engineer's certificate, and subsequently became chief engineer to the Nordenfelt Submarine Boat Company. In that capacity he became associated with the early development of the submarine.

In 1887 Nordenfelt secured from the Turkish Government an order for two submarines 100ft. in length and driven by steam engines of 250 I.H.P. These vessels were laid down at Chertsey, and were sent out to Constantinople in sections in charge of Captain Garrett and Mr. d'Alton. One of them was duly assembled and carried out a series of trials in the Golden Horn and Sea of Marmora. When submerged the vessel proved very difficult to handle, and once, when a torpedo was fired from her, her bow was thrown up, the water in the boilers and tanks ran aft, and the submarine took a downward plunge stern first, at an acute angle. Mr. d'Alton and his companion, however, kept their heads and succeeded in bringing the boat to the surface. About this time Nordenfelt became associated with the Barrow Shipbuilding Company. An improved submarine having a length of 125ft. was produced. On her trials this vessel developed a surface speed of 14 knots and a submerged speed of 5 knots on a horse-power of 1300. This vessel was eventually sold to the Russian Government, but on the way out to Cronstadt ran on to the Horns Reef and had to be abandoned.

Colonel d'Alton's association with the sea and marine engineering did not survive these exciting experiences. He turned to electrical engineering, and was appointed engineer-in-chief to the London Electric Supply Corporation, in which connection he was intimately associated with the erection of the Deptford Power Station. On the outbreak of the South African War he took up military service, and reached the rank of Major in the 6th Battalion of the Royal Irish Rifles. When the campaign was over he returned to this country, and for two years served as chief engineer to the Central London Railway. In 1903 he joined the staff of Dick, Kerr and Co., Ltd., as chief mechanical engineer, a post which he retained until 1914, when he set up in private practice as a consulting engineer. During the period of his engagement with Messrs. Dick, Kerr, he supervised the contract for the electrification of the Liverpool–Southport branch of the Lancashire and Yorkshire Railway and other railway and power schemes in various parts of the world. From 1916 to 1921 he served as chief engineer to the Valuation Committee under the Ministry of Munitions, and subsequently under the Board of Inland Revenue. At the end of that engagement he resumed his private practice, in the execution of which he made several trips abroad.

Colonel d'Alton was a member of the three principal engineering institutions. He joined the Institution of Mechanical Engineers in 1881, the Institution of Electrical Engineers in 1896, and the Institution of Civil Engineers in 1899.

Literature.

The Chronicles of Boulton's Siding. By A. R. BENNETT. London: The Locomotive Publishing Company, Ltd. 1927. Price 6s. 6d.

REAL as it was to locomotive engineers, railway men and contractors of the middle of last century, Boulton's Siding is only a name and nothing more to the present generation. It disappeared in the 'eighties, primarily perhaps because the man who had built it up, Isaac Watt Boulton, overcome by the death of his son, who had worked shoulder to shoulder with him for years, lost his interest in the business, but not a little because it had outlived its time and the competition of other firms had robbed it of what was at one time a unique position. The mainstay of the concern was the hiring out of locomotives for all sorts of jobs, generally to contractors, but occasionally to railway companies. What Boulton did was to buy up old locomotives, refit them, and then let them out. For a score of years that was a profitable business, and engines were sent on hire to all parts of the kingdom. But when new builders of small locomotives sprang up in various parts of the country, Boulton's business declined, and, as we have already observed, died in the 'eighties.

But besides the repair and hiring out of old engines Boulton built a fair number of new engines, or so far converted old stock that it became practically new. An instance of particular interest is his conversion of some of Sturrock's steam tenders, five of which he bought after they had been in use but relatively few years. He practically rebuilt them, and in place of the tanks which they carried he put the type of water-tube locomotive boiler with which his name is associated. This boiler had a long central flue, rather like that of a Cornish boiler but provided with a great number of small cross tubes placed diagonally. It was claimed for it that it was a good steamer, and Boulton laboured hard to make it a success, but the difficulties of repair were considerable, and the failure of a single tube put the engine out of commission. Boulton's devotion to the design contributed in part, it would seem, to his ultimate failure, for he persisted with it, despite the trouble which it gave to his customers.

The nature of Boulton's undertaking led to many famous and notable engines passing through his hands, and his Siding was in its palmy days a veritable museum. Who has not heard of "Fowler's Ghost"? "The last broad-gauge locomotive dealt in by Boulton," writes Mr. Bennett, "was a very famous machine, celebrated, contrary to usual rule, not for what it did, but for what it didn't do. In fact, it never did anything at all, and was perhaps on the whole the most mysterious and elusive of railway motors. If everybody concerned had done his level best to cover up traces and confuse the record, greater success in those directions could scarcely have been attained." The engine was designed to operate on the Metropolitan Railway, where it was feared that passengers would be asphyxiated by the fumes in the tunnels. It was built by Stephensons in 1861, and cost, it is said, £4500. It was tested and failed, and for many years no one knew anything about it. Then Stephensons, hunting through old records, found the drawing. It shows a 2–4–0 engine, with 15in. by 24in. cylinders, and a remarkable boiler. The tubes, at the smoke-box end, were very short, only 2ft. 7½in. long, and between them and the fire-box was a long cylindrical combustion chamber. This chamber was liberally lined with fire-bricks, and the idea was that the heated bricks would maintain steam in the tunnels. Mr. Bennett devotes several pages to chatting about this engine, and reproduces the Stephenson drawing.

In this volume may be found particulars of many engines of weird and wonderful design, with all sorts of boilers, and from a mere survey of the illustrations one may put himself into touch with the past and the marvellous collection which passed on its way to oblivion through Boulton's Siding. Mr. Bennett writes as a real lover of locomotive history, and with that intimate knowledge of all the engines which were ever made that characterises your real enthusiast. Moreover, he has an easy conversational style. For example, writing of one of Boulton's "transformations," he says: "A committee of Royal Academicians might not have unanimously approved of the design of the tank, perhaps, but it is understood to have been improvised in a hurry. It rather looks as if practical Mr. I. W. Boulton had remorselessly confiscated the domestic cistern in his anxiety to fill the order."

The substance of the volume appeared originally as a series of articles in the *Locomotive* between November, 1920, and February, 1925, during the publication of which many new facts came to light, and have now been incorporated into what must be an almost complete chronicle of Boulton's Siding, and is certainly a book which no lover of the history of locomotives should be without for a day longer.

SHORT NOTICES.

Die Luftvorwärmung im Dampfkesselbetrieb. By Dipl.-Ing. Wilhelm Gumz. Leipzig: Otto Spamer. 1927. Price 10 marks.—This book is a recent addition to a most interesting series of monographs on technical aspects of boiler firing, and we can recommend it to engineers who have a knowledge of the German language. The author points out that modern boiler design is becoming more and more dependent on an exact knowledge of the theoretical principles underlying the process of combustion, and in this volume he deals with problems connected with the use of preheated air and the design of air heaters generally. Fuels and the process of combustion are briefly touched upon, after which the effect of combustion temperature is discussed, graphical analytical methods being introduced and numerical examples given. Boiler output and efficiency are dealt with, and some difficulties associated with preheated air are mentioned. Some typical boilers designed to use highly heated air are then described and illustrated, after which a very complete illustrated account of various types of air heaters is given. The different factors which enter into the design of air preheaters are discussed and a numerical example is given along with some test results. The book closes with a brief historical survey of the progress made in the practice of air heating, and it is worthy of of note that full recognition is given to English workers in this field.

BOOKS RECEIVED.

Cutters and Cutter Blocks. By S. Ransome. London: Ernest Benn, Ltd., 154, Fleet-street, E.C. 4. Price 12s. 6d. net.

Gottlob's Technology of Rubber. Translated by J. L. Rosenbaum. London: Maclaren and Sons, Ltd., 37, Shoe-lane, E.C. 4. Price 42s. net.

The Craft of Tracing. London: The Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's-square, S.W. 1. Price 2s. net.

La Machine Locomotive. Eighth edition. By E. Sauvage. Paris: Librairie Polytechnique Ch. Béranger, 15, Rue des Saints-Pères. Price 50 Fr. 50.

E.H.T. Switchgear and Breakers. By G. L. E. Metz. London: The Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's-square, S.W. 1. Price 2s. net.

Year Book and Directory of the South African Mining and Engineering Journal, 1927. London: Argus South African Newspapers, Ltd., 72, Fleet-street, E.C. 4. Price 10s. 6d. net.

La Société des Ingénieurs Civils de France: Mémoires et Compte Rendu des Travaux. Bulletin de Septembre–Octobre, 1926. Paris: Hotel de la Société, 19, Rue Blanche, 9e.

Manuel des Laboratoires Sidérurgiques: Méthodes Analytiques Conventionnelles de la Communauté Arbed Terres-Rouges. Brussels: J. Lebègue et Cie., 36, Rue Neuve. Price 5s. 6d. net.

SIXTY YEARS AGO.

WHAT, we asked in the opening paragraph of an article in our issue of April 12th, 1867, is "wirbel-bewegung"? We were, we are afraid, a trifle flippant on the subject. It had, we said, just been disclosed that everything in the whole of the universe was, root and branch, wirbel-bewegung—everything and everyone from the editor of this journal to the printer's devil, from Landseer's lions to Balaam's ass, from the Cock Lane Ghost to the Thirsty Woman of Tutbury. We will not, however, maintain the reader's suspense through several crowded paragraphs as we did sixty years ago, but will at once reveal the fact that wirbel-bewegung is vortex motion. Our article was based on a communication which Professor Sir William Thomson—Lord Kelvin to be—had submitted to the Royal Society of Scotland (*sic*) dealing with vortex motion in a perfect fluid. Thomson, following earlier work by Helmholtz, argued that in a fluid destitute of viscosity a vortex once created would persist for all eternity. With characteristic boldness, he suggested that in vortex rings were to be found the only true atoms, and characterised as "monstrous" the assumption that atoms were composed of infinitely strong and infinitely rigid pieces of matter. He contemplated a full mathematical investigation of the mutual action between two vortex rings passing one another. The problem, he said, was perfectly solvable mathematically, and the novelty of the circumstances would present difficulties of an exciting character. In the development of the subject, he foresaw a new kinetic theory of gases. He was in a position to prove that if two vortex rings were interlinked, nothing could ever separate them, and that however much such a double atom might vary in shape, it would always remain essentially the same. Sir William Thomson believed that in the existence of vortex rings in the ether he had found a new basis for the conception of the atom. The atom was no longer a question of matter, but of energy. In common with others, he was beginning to find it difficult to explain the fundamental facts of the growing science of electricity on the traditional assumption that the ultimate particles of matter were hard, rigid lumps. That assumption was regarded as crude by Thomson and other advanced thinkers, and was being discarded for an alternative conception involving nothing but ether and energy. Advanced thought to-day adheres to that view, but Thomson's vortex rings are no longer favoured as a means of expressing it. Within recent years, however, the detailed mathematical investigations made both by Thomson and Helmholtz into the behaviour and characteristics of vortex motion have received a new and important application in aerodynamic theory.

Paint-making Machinery.

No. II.*

In the previous article we described the processes of roughly mixing together the various ingredients of a paint, and we now go on to explain the milling process, the object of which is to insure the complete envelopment of each particle of the pigment with a film of the vehicle, and to insure an even texture throughout the mass.

A typical example of the plant for this purpose is illustrated by Fig. 5, which shows some of the machines in the London factory of Thomas Hubback and Co., made by Torrance and Sons, Ltd., of Bitton, near Bristol. In this view the edge runner, already described, which performs the preliminary mixing, is raised on a staging behind the man seen standing on the top of the ladder. The edge runner delivers its charge into a mixer at the level of the man's feet, and the mixer gives a continuous discharge to the grinding mill in the foreground.

Except for very small outputs grinding mills are now almost exclusively of the triple roller type, an example of which, driven by an electric motor, is illustrated by Fig. 6; but sometimes—as shown in Fig. 5—two triple-roll mills are combined in tandem to form one machine.

The action of a paint mill is not purely rolling but rather one of rolling and tearing, as the pairs of rolls run at different speeds, and it is this difference in speed which practically limits the number of rolls in a group to three. Thus, the first roll must run at such a speed that it will feed forward a reasonable amount of paint, while the last roll must not run so fast that the paint will be thrown off by centrifugal action. There must, nevertheless, be a considerable ratio between the speeds of the adjacent rolls, and it is found that these desiderata cannot be met if more than three rolls are employed. As a consequence it follows that, if the passage between three rolls is not sufficient to complete the grinding, the paint must either be returned to the feed end of the machine again, or be passed on to another triple-roller mill.

* No. I. appeared April 8th.

In its passage through the mill the paint always adheres to the faster running of two rolls, so that when it is fed in at the top between the two back rolls, it is carried round underneath the second, faster-running roll, and is finally delivered over the top of the third high-speed roll, from which it is scraped by a doctor knife. The tearing or shearing action to which the material is subjected in its passage between the different sets of rolls produces the desired mixing or milling effect.

It will be readily understood that, with such fine material as pigments, the rolls must be set very close together if no particle is to escape being acted upon in passage, and considerable ingenuity has been devoted to the design of gear which will insure the accurate setting of the rolls.

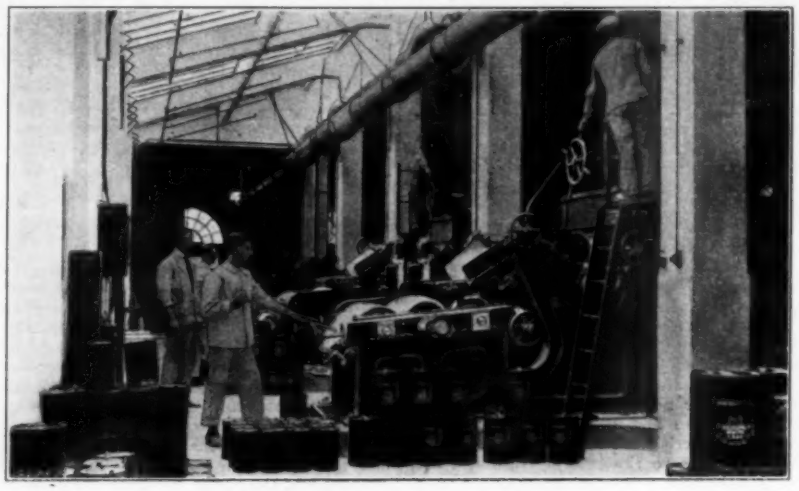


FIG. 5—COMBINATION PAINT MILL—TORRANCE

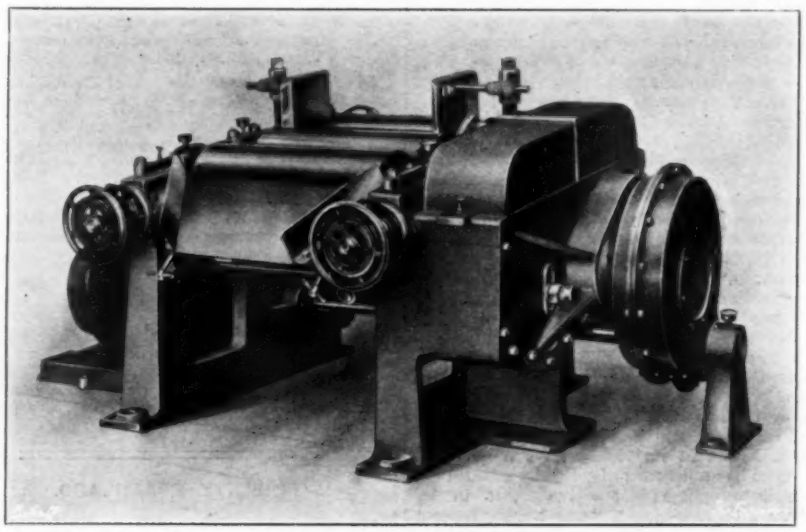


FIG. 6—TRIPLE ROLLER MILL—TORRANCE

In the "Torrance" mills the adjustment of the rolls is affected by means of an accurately registering micrometer gear, operating in conjunction with a controlled pressure spring. The spring is powerful, and is compressed by means of the large nut shown in front of the lock wheel in Fig. 7, which illustrates the complete gear as applied to a triple roller mill. When compressed, the spring is operative to prevent the pigment forcing the rolls apart, but, as the spring is always working within its safe elastic limit, a foreign substance, such as a nail, will force open the rolls and pass through without damaging the machine. The spring is compressed to an extent determined by the makers, according to the size of the machine, but a compression-registering device is fitted so that a wide adjustment of spring pressure can be obtained, and all springs on a machine be adjusted to the same pressure.

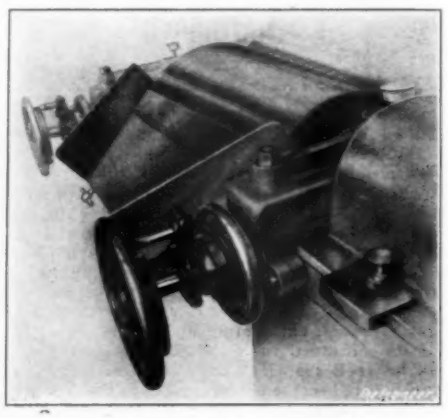
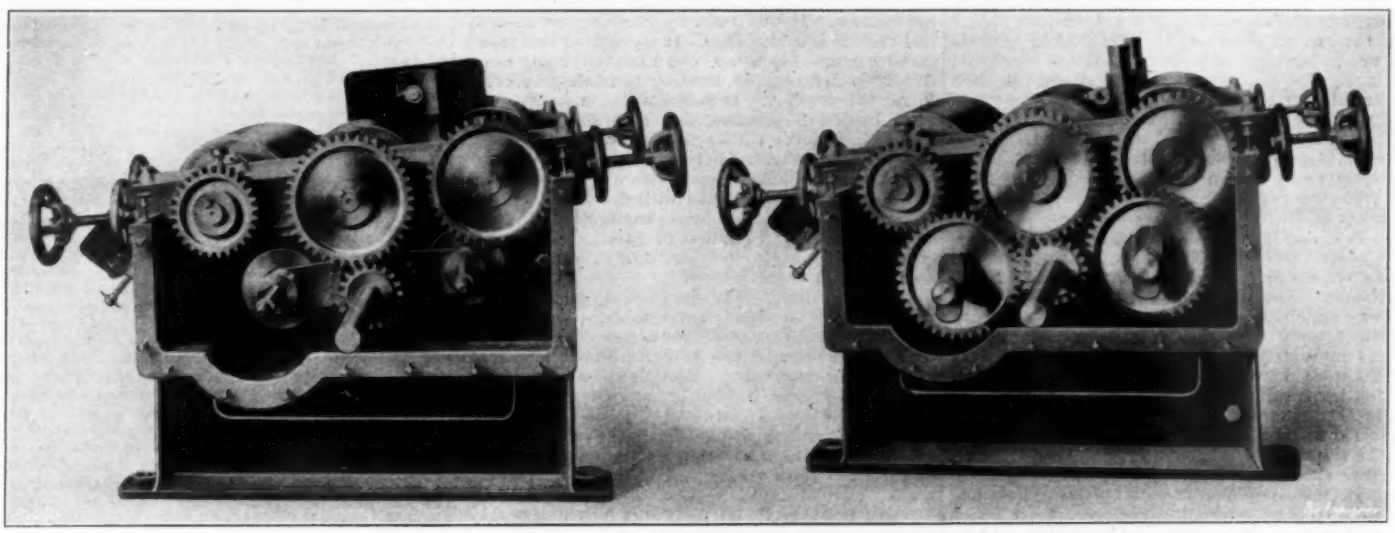


FIG. 7—MICROMETER ADJUSTMENT

The micrometer-adjusting screw operates through a tube upon which the spring is threaded, the back of the tube being flanged so that the spring is drawn into compression against the head of the frame by means of the nut. The adjusting screw, which passes



FIGS. 8 AND 9—DRIVING GEAR FOR TRIPLE ROLLER MILL WITH COVER REMOVED—TORRANCE

through the screwed tube and bears against the sliding roll bearing, can be adjusted by means of the calibrated hand wheel mounted thereon, so that the rolls are brought into actual contact with scarcely any pressure on the roll surfaces. Unnecessary pressure grinds them away and destroys their truth, but the springs offer great resistance to the rolls being forced apart. Hence the pigment cannot pass the rolls without being reduced, while wear and tear are reduced to a minimum.

The gear is so designed and arranged that the force of the spring can be released on to the roll contacts in degrees of pressure as required by the nature of the material being treated. In practice the range varies from zero, at which setting the rolls are just in contact to 3 deg. of pressure, according to the calibrations on the hand wheel registering with the pointer. The rolls can be adjusted to accurate non-contacting conditions, the calibrations registering clearance between the rolls in thousandth parts of an inch, so that parallel adjustment can be easily obtained, which insures consistent grinding from end to end of the rolls. The gear is easily re-set to a feeler gauge when necessary.

The rolls themselves are generally of chilled cast iron, although granite and other stones are sometimes used, and are usually hollow when of iron, so that they may be water-cooled if necessary. The iron rolls are rough-turned and then allowed to season for some time, to release internal strains. They are then ground and tested for truth, which must be within about half a thousandth of an inch, and finally buffed while running in their own bearings.

In order to prevent the rolls wearing into grooves, the centre roll is given a reciprocating movement along its axis by means of a cam. In the Torrance mill this cam is not fixed to the frame, but floats on the spindle. It is keyed to a gear wheel and is driven by a train of gears at a comparatively slow speed. The result is a sort of creeping action which brings the endways movement of the roll to a different position round the periphery at every stroke, and prevents the possibility of flats being worn on the roll. The gear wheels and cam are arranged in a cast iron casing and are flooded with oil.

The main driving gear for the rolls is well illustrated by Figs. 8 and 9, from which it will be seen that all the wheels are covered by a substantial cast casing. The driving shaft is in the centre at the bottom, and is geared directly with the cente roll. A second pinion behind the one driving the centre roll meshes with two wheels on either side, which are mounted on arms—see Fig. 9—pivoted round the main shaft. The left-hand wheel drives the high-speed roll, while there is a reducing gear on the right for the low-speed roll. The intermediate wheels are, of course, mounted on the arms so as to accommodate the adjustment of the rolls. All the wheels have machine-cut teeth and run in an oil bath.

Between the first and seond rolls, where the paste is first fed into the mill, there is arranged a pair of side boards to prevent the paint escaping over the ends of the rolls. These boards are made of wood and are carefully fitted to the contour of the rolls. They are mounted on slides so that their distance apart can be adjusted to suit the quantity of paint being milled, and are tied together, for the sake of rigidity, by an overhead bar, which incidentally provides a very convenient means for cleaning the attendant's palette knife.

The doctor or scraper knife, which removes the paint from the last roll, is a flat steel plate with a hardened edge, and is carried by arms pivoted on the necks of the bearings carrying the roll, so that it moves with the roll as the latter is adjusted, and the proper bearing of the knife on the roll is not disturbed. The angle at which the knife is presented to the roll can be adjusted by swinging the arms round on the bearing necks, and a screw adjustment is provided to regulate the pressure of the knife. The adjusting screws are arranged on swivelling arms, so that they may be readily moved out of the way to allow the doctor to be swung back for cleaning without disturbing the adjustment.

Mills of this type are generally made with rolls ranging between 7in. and 18in. diameter, and from 12in. to 36in. length, and may have outputs up to 10 tons per day.

(To be continued.)

Welded Repairs to Princes Bridge, Melbourne.

IT was recently found necessary to strengthen the structure of Princes Bridge, Melbourne, to make the bridge available to carry heavier traffic. The strengthening was rendered necessary by the decision to run electric trams over it. The bridge—see Fig. 1—which is at the main entrance of the city, carries the largest volume of traffic over the river Yarra, and embodies a double-track cable tramway. It is 120ft. in width, was built over fifty years ago, and consists of three river spans each of ten arched girders carried on masonry piers, and—on the south side—a land span of 24ft. over a roadway on the river bank. The latter part of the bridge is carried by ten iron girders spanning the road, on which a series of continuous girders at 4ft. 6in. centres are supported with buckled plates riveted to the top flanges to carry the road bed.

An examination was made of the structure to decide whether it would carry the increased loading due to the much heavier cars. The main girders are 3ft. deep, built up with 15in. by ⅝in. flange, ⅝in. web plate, 3in. by 3in. by ⅝in. angles, stiffened with 5in. by 3in. by ⅝in. tee irons at 6ft. centres, the rivets throughout being of ⅝in. diameter and 4in. pitch. The engineers found that the rivets in the top and bottom flanges would be over-stressed in the two centre girders on which the tramway load concentrated, and, with a view to obviating the expense and lost time which would be entailed by closing the road to replace these girders, the possibility of relieving the rivets by welding the angles to the flanges and webs was considered. The conclusion arrived at was that 3in. tack welds at 6in. intervals having a shearing strength of at least 4 tons per

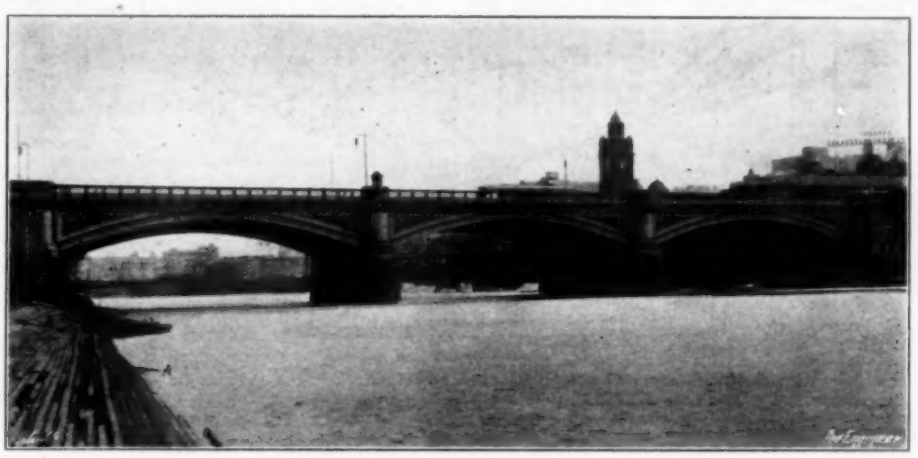


FIG. 1—PRINCES BRIDGE, MELBOURNE

lineal inch would be ample for the purpose, and it was decided to have that work done.

When the scaffold planks were hung up, however, a close inspection of the girders disclosed a much more serious state of affairs than had been anticipated. The transverse or floor girders are 12in. deep, built up of 9in. by ⅝in. flange plates, 12in. by ⅝in. webs, and 3in. by 3in. by ⅝in. angles, covered in with ⅛in. arched plates riveted to the top flanges of the transverse girders. The cable tramway rope slots run at right angles to them and are open to the surface, the slots for both the up and down lines happening to run almost directly over the centre lines of the two middle girders, with the result that the tops of those girders have been kept constantly covered with wet street refuse. The acid moisture from this refuse had worked under the transverse floor girders and practically converted the packing or bearer plates wholly into oxide,

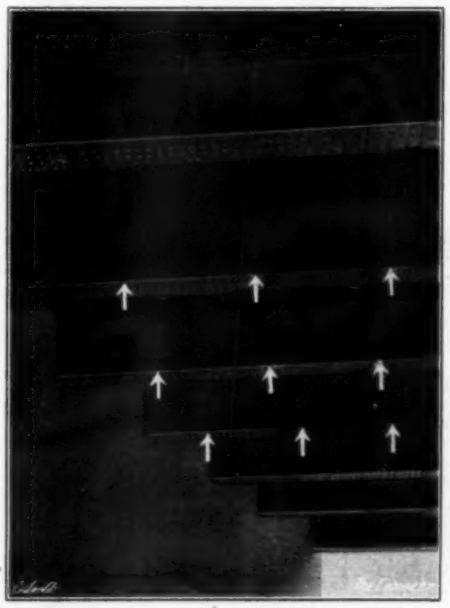


FIG. 2—STRENGTHENING WEB PLATES OF MAIN GIRDERS

the swelling of which had bent the flanges of the main girders downwards from ¼in. to ⅜in., giving them a permanent set. This defect was aggravated by the cable tramway steel ropes dragging over the tops of the transverse floor girders, owing to the gradual settlement of the road approach to the bridge, and in course of time the ropes had worn through the top flange and cut their way down through the double angle irons to the centres of the rivet holes.

The transverse girders were originally continuous for the width of the bridge, but the cutting through of the top flanges in this way had concentrated the loading on the flanges of the main girders and thus helped the deformation, at the same time buckling the web plates of the two girders immediately under the slots and the two girders adjoining them on either side.

This extensive damage was reported, and it was suggested that the oxidised bearing plates between the top flanges of the four main girders and bottom flanges of the transverse girders at all the intersections should be cut out, that new fitted wedge pieces should be driven in and that the whole should be welded together externally so as to give a solid bearing and to seal the joints against further access of moisture.

To strengthen and straighten the web plates of the main girders it was decided to place new tee iron stiffeners at each side of the web plates under each of the transverse girders. They were welded to the web plates and their ends welded to the flanges at top and bottom, as shown by the arrows in Fig. 2. The joggled stiffeners between the top and bottom flanges, instead of being forged in the usual way, were made by cutting four notches in a straight tee bar—see drawing A in Fig. 3—and the bar bent to close the notches, which then assumed the required shape—see drawing B. When in position the tee was first welded to the web plate, the notches being left unwelded. Then, with cramps, the top and bottom were closed to the girder flanges and welded to them. This left the notches a little more open or closed as the fit and shape required, and finally the four notches were welded solid.

To provide for the overstressed riveting a fillet weld was run along the edges of all the angle irons. It was intended only to use tack welding for this purpose, but on chipping off the paint and scale a distinct undercut all along the edge of the angle iron was found, so the welds were made continuous to compensate for it. The top flanges of the transverse girders, where cut by the ropes, were repaired—when the change-over to electric trams was effected and the ropes removed—by welding 12in. lengths of angle iron to the undersides of the damaged flanges, thus making them continuous once more.

Nearly a ton of new material was put into the four girders, in the shape of new stiffeners, wedges and bearing plates. The actual welders' time on the job was 240 hours, employing the electric arc process and 3800ft. of Quasi-Arc No. 10 electrode. The work was all done from a hanging stage under the girders, so that there was no interference with the continuous traffic either above or below.

The cost of the job was £480, more than half of which was absorbed by the cost of labour, chip scaling the old

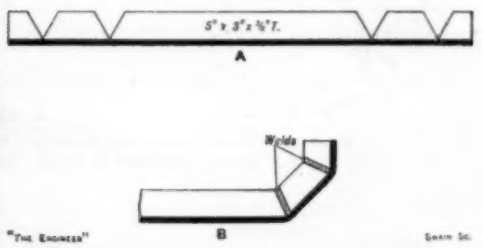


FIG. 3—FORMATION OF JOGGLED STIFFENERS

metal, fixing the hanging stage, bringing in electric current leads and re-painting. The cost is regarded as being extremely low considering the result obtained, for to effect the repair by the usual methods the girders would have had to be replaced, with the consequent cost of breaking up the surface and the stoppage of traffic.

AN article in a recent issue of the *South African Mining and Engineering Journal*, by Dr. P. A. Wagner, reviews the prospects of the iron and steel industry of the sub-Continent and gives the following list of the major occurrences of iron ore :—(1) The so-called magnetic quartzite of the Pretoria series, which is estimated to contain 4,500,000,000 tons, averaging between 42 and 53 per cent. of iron ; (2) the deposits on the Daspoort horizon, north of Potchefstroom, which contains reserves of the order of 1,000,000,000 tons ; the ore is of much the same grade as the magnetic quartzite, but is not so satisfactory in the blast-furnace ; (3) the Crocodile River deposits, situated 90 miles north-east of Pretoria, which contains reserves of the order of 100,000,000 tons of the purest hematite ; (4) the deposits of the Klipfontein-Thakweneng and Gamagara ridges near Postmasburg, which contain reserves of the order of 30,000,000 tons of hematite of the same grade ; (5) the great segregations of titaniferous magnetite of the Bushveld complex, exposed 10 miles north of Pretoria, which probably contain a bigger reserve than all the other deposits put together. Unfortunately, the ore is highly titaniferous. It has been shown, however, that the titanium could be fluxed by silica, and it is probable that, ultimately, these ores would be smelted on a very big scale in admixture with the siliceous Pretoria ores.

ENERGY DIAGRAMS AND COMPARATIVE RESULTS FOR THE MARINE OIL ENGINE TRIALS

(For description see opposite page)

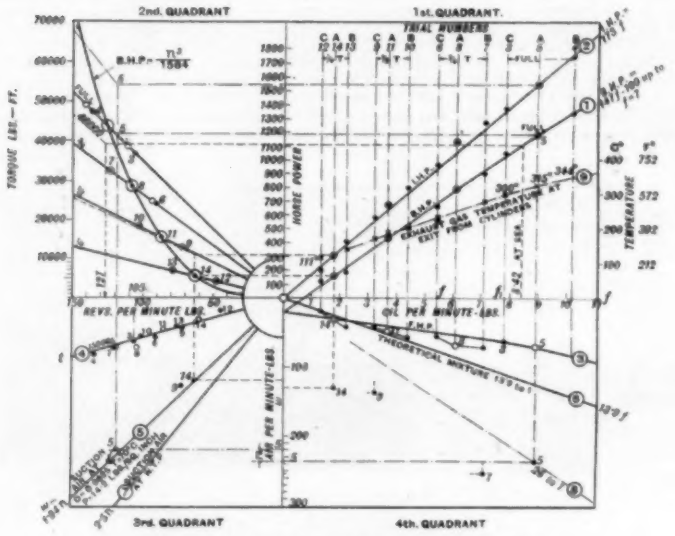


FIG. 1—M.V. Sycamore, First Report Inst. Mech. Eng., 1924.
S.A. 4-Stroke 6-Cyl. Richardsons-Tosi Engine. Air Injection.

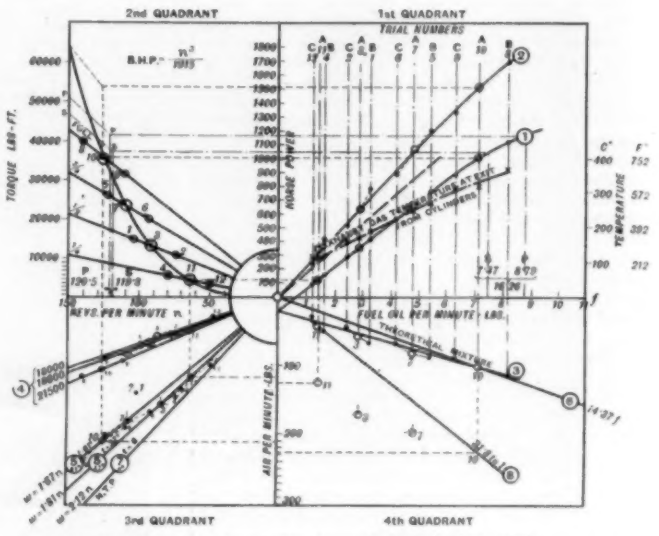


FIG. 2—M.V. Cape York, Fifth Report Inst. Mech. Eng., 1926.
S.A. 4-Stroke 6-Cyl. Hawthorn-Werkspoor Engine. Air Injection.

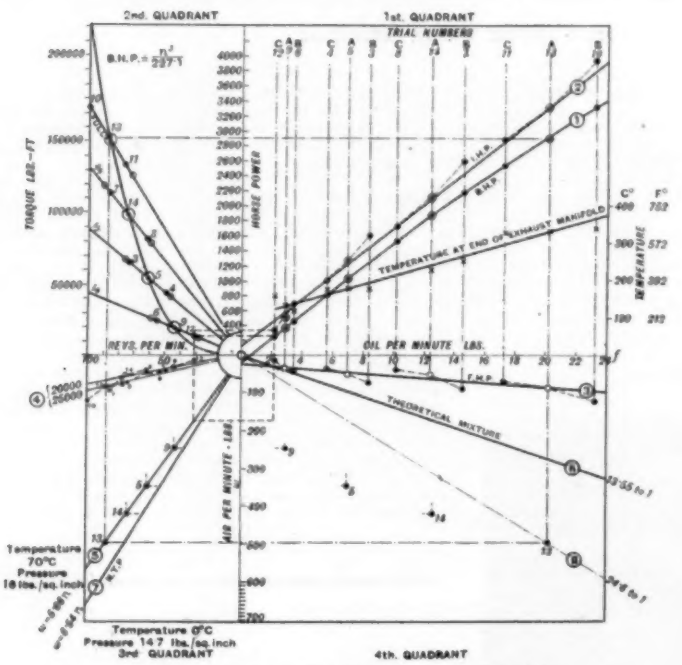


FIG. 3—M.V. Pacific Trader, Third Report Inst. Mech. Eng., 1926.
S.A. 2-Stroke 4-Cyl. Doxford Engine. Airless Injection.

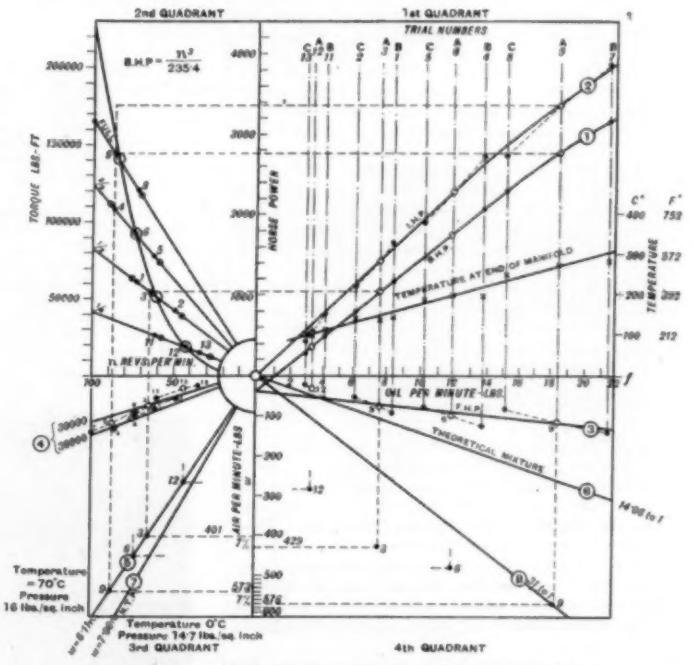


FIG. 4—M.V. British Aviator, Fourth Report Inst. Mech. Eng., 1926.
S.A. 2-Stroke 6-Cyl. Palmer-Fullagar Engine. Air Injection.

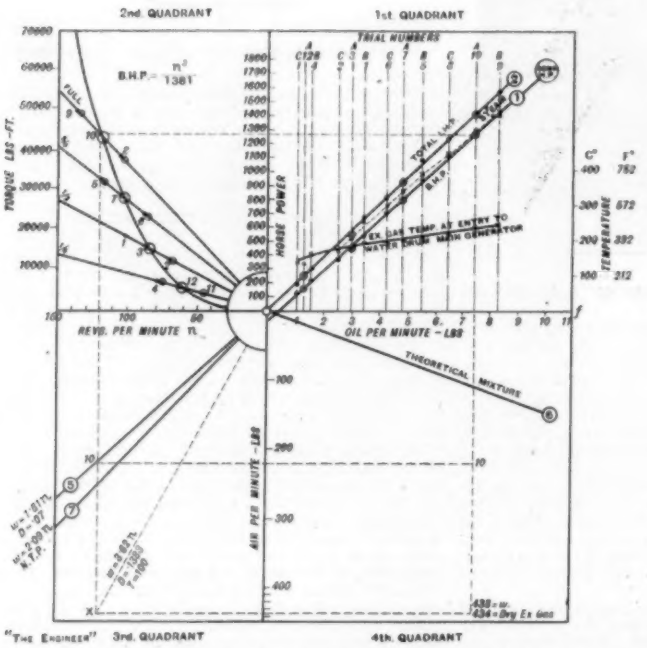


FIG. 5—M.V. Dolius, Second Report Inst. Mech. Eng., 1925.
S.A. 2-Stroke 4-Cyl. Scott-Still Engine. Airless Injection.

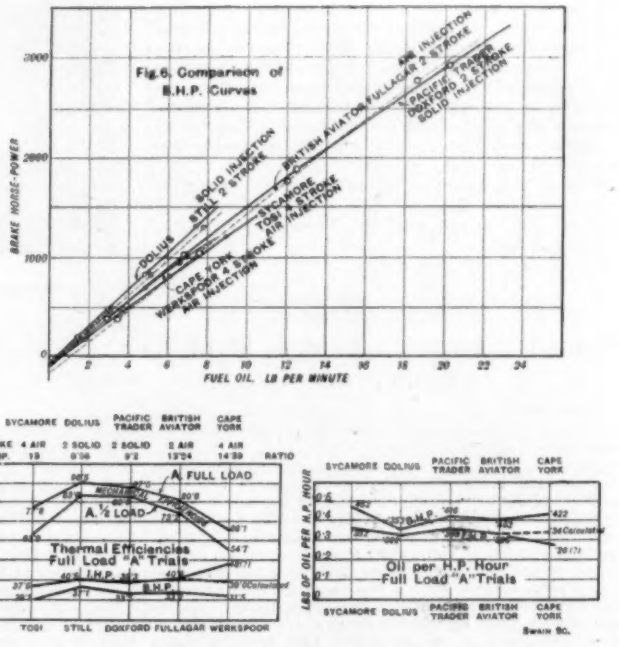


FIG. 7—Thermal and Mechanical Efficiencies and Oil Consumptions.

A Characteristic Oil Engine Energy Diagram and the Marine Oil Engine Trials.*

THE paper which is summarised in the following article originated from an independent study of the reports of the Marine Oil Engine Trials Committee appointed in 1922 by the Institution of Mechanical Engineers and the Institution of Naval Architects, with representatives from the Admiralty and the Institution of Marine Engineers, to carry out tests of oil engines and oil-engined ships. The pages of tables, figures, and numerous diagrams which of necessity are used to record the results of an oil engine trial require close study to extract from them the characteristics of the engine. The characteristic energy diagram for an oil engine devised by the author and illustrated in Figs. 1 to 5 on page 420 seeks to present the results of the marine oil engine trials in a form which co-ordinates all the variables in one single diagram. The variables of such a trial include the following items:—The brake horse-power, the indicated horse-power, the fuel oil fed to the engine per minute, the air supply, the speed of the engine, the external load, measured by the torque applied to the crank shaft by the brake. Of these, load and speed are the independent variables. In general the selected load is applied to the engine and fuel oil fed to it until the speed is brought to the selected value, the other quantities meanwhile ranging themselves in co-ordination.

METHOD OF CONSTRUCTING THE DIAGRAM.

The method of constructing the characteristic energy diagram can be conveniently followed from the following summary:—

(1) Draw axes at right angles; choose scales suitable for the size of the engine, namely, horizontally to the right, fuel per minute; horizontally to the left, revolutions per minute of the crank shaft; vertically upwards, horse-power; and vertically downwards, air per minute.

(2) Calibrate the second quadrant for torque by a family of lines radiating from the origin to a scale conveniently placed on the left. Then any point taken at random in this quadrant defines a torque, a speed, and a power by reference to the appropriate scales around it.

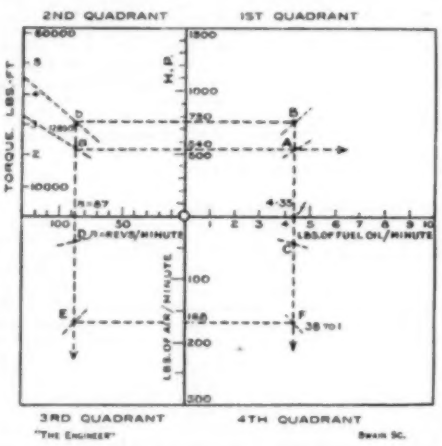


FIG. 8—THE CO-ORDINATING RECTANGLE

(3) Plot the B.H.P. against oil fed to the engine per minute.

(4) Plot the I.H.P. against the oil fed to the engine per minute. (Failing direct measurement of I.H.P., determine the curve by calculation as shown in the paper.)

(5) Plot the air-speed curve in the third quadrant from direct measurements of suction temperatures and pressures, or, failing these data, estimates of the density of the air in the cylinder at the beginning of compression. The diagram is complete, since the air-fuel curve can be plotted for given conditions by completing the construction of a sufficient number of co-ordinating rectangles, remembering that the bottom horizontal line has a break in it as it crosses the air scale if the oil is fed to the engine in an air blast. The bottom horizontal line is without a break for solid injection engines.

(6) If reliable exhaust gas analyses are available from which the weight of air in the cylinder at the beginning of compression can be computed, then a corner of the co-ordinating rectangle is fixed, and projectors to the left from several such points fix the air-speed curve or curves from which the suction temperature can be calculated when a light spring diagram is available from which to get the suction pressure.

(7) The results of a single experiment may be co-ordinated by the co ordinating rectangle Fig. 8 as follows:

The B.H.P. is assumed to be determined together with fuel consumption f and speed.

(*a*) Find f on the fuel axis and draw a vertical to intersect the B.H.P. curve in A.

(*b*) From A draw a horizontal to meet the vertical through the speed in *a*. A line from the origin through *a* is a line of constant torque, and the value of the torque is $\frac{\text{B.H.P.} \times 5250}{n}$.

(*c*) Calculate w, the weight of air drawn in from the air density at the beginning of compression, and the suction displacement, thereby fixing the point E. A line from the origin through E is a line of constant density.

(*d*) Draw a horizontal line through E to meet the vertical through f in F. A line from the origin through F is a line of constant mixture.

(*e*) Alternatively determine F from an exhaust gas analysis and project to the left to fix E. The co-ordinating rectangle for one experiment is then fixed.

Additional lines and curves may be added for the study of particular problems. Amongst these may be mentioned the theoretical air line in the fourth quadrant derived from the fuel analysis. It is a line of constant mixture. Also the air-speed line corresponding to normal temperature and pressure in the third quadrant. A vertical intercept between any air-speed line and the axis, and the corresponding intercept between the N.T.P. line and the axis, furnish data from which the volumetric efficiency may be calculated.

There are also frictional torque lines, frictional H.P. lines which give insight into the working of the engine.

SHORE TRIALS.

In the second part of the paper the diagram is first developed from the data provided by the ashore trials of the engines of the Sycamore. The weight of air charged to the engine is deduced from the trial observations, and after calculation an allowance of 7 per cent. is made for the additional injection air. This is shown on Fig. 1. As a guide to the estimation of the suction temperature of the air, failing its direct measurement, a diagram prepared by the author is reproduced from the 1914 Report of the Gaseous Explosions Committee of the British Association, giving cases for directly measured suction temperatures for various air to gas mixtures for two different speeds of 100 and 200 r.p.m. Comparing the mixtures used in the Sycamore engines and those of the experiments recorded on the diagram, a temperature of 70 deg. Cent. is selected as the probable air suction temperature. This value is also used for some of the other engines. Some points which emerge from a study of the diagram for the Sycamore—Fig. 1—are certain linear relations of the diagram, which show that the I.H.P. is proportional to the fuel fed to the engine. It will also be seen that the B.H.P. curve is linear over a wide range of fuel consumption, but that it does not pass through the origin. The air delivered per minute is also a linear function of speed over a wide range of engine speeds, while the frictional torque is constant over a considerable fuel range.

From the linear relations aforementioned and the slope of the I.H.P. and B.H.P. curves the author deduces a mathematical method of calculating the I.H.P. from determined values of B.H.P. and the fuel consumption of the engine. It is suggested that such a method as that evolved may be useful when means for determining the I.H.P. of an engine directly are not available or when the determined results are doubtful. As a case in point the method is applied in the paper to the engine of the Cape York, in the trials of which errors in the determination of the I.H.P. were suspected and afterwards proved to be probably caused by the particular indicator rig employed, which was cam driven from the cam shaft of the engine.

The diagrams for each of the engines tested by the Committee are in turn described and they are reproduced in Figs. 1 to 5 opposite. The Sycamore results are perhaps more fully worked out than are those of some of the other engines, but in each case a concise account of the leading features of the engine is given and points of interest arising out of the diagrams are discussed.

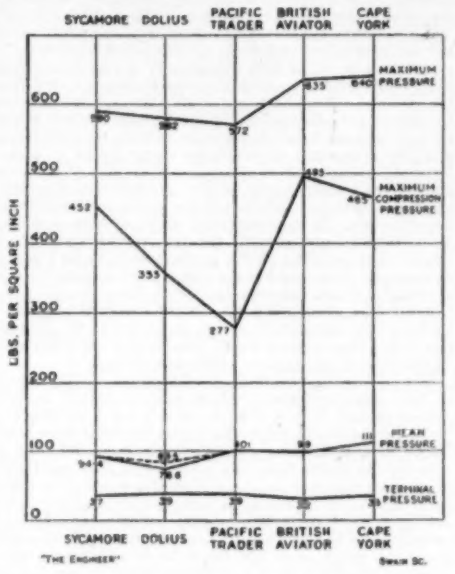


FIG. 9—A COMPARISON OF PRESSURES

COMPARISON OF THE RESULTS.

The third part of the paper is almost wholly devoted to a comparison of the results deduced from the trial data and the characteristic energy diagrams drawn for the different engines, and these are summed up in the curves which are reproduced in Figs. 6 and 7 on the opposite page, Fig. 9 and the tables Nos. I. to VII.

The curves reproduced in Fig. 6 are important as showing the B.H.P.'s of the various engines plotted on a base of fuel oil delivered to the cylinders in pounds per minute.

TABLE I.—*The Adjusted Mechanical Efficiencies of the Engines Developed in the A Trials.*

	Sycamore, 4-stroke.	Dolius, 2-stroke.	Pacific Trader, 2-stroke.	British Aviator, 2-stroke.	Cape York, 4-stroke.
Quarter load	54	58	73	78	41
Half load	70	81	85	84	61
Three-quarter load	74	91	92	87	65
Full load	83	94	92	91	71

I.H.P. measured in the Sycamore, reduced by the compressor H.P., Table 13A of the Committee's report.
I.H.P. measured in the Dolius, reduced by electrical input to steam valve pump, to rotary scavenge blower, and by I.H.P. developed from steam, Table 23 and Table 10 of the Committee's report.
I.H.P. measured in the Pacific Trader, reduced by scavenge pump H.P., Table 11 of the Committee's report.
I.H.P. measured in the British Aviator, reduced by air compressors and scavenge pump H.P., Table 14 of the Committee's report.
I.H.P. measured in the Cape York, reduced by the air compressor H.P., Table 10 of the Committee's report.

TABLE II.—*Comparison of Calorific Values and Air Required.*

Gross calorific values, B.Th.U.	19,320	19,540	18,250	19,120	19,190
Air/lb.	13·9	14·5	13·55	14·06	14·37

TABLE III.—*Thermal Value of a Cubic Foot of Cylinder Volume.*

Probable density of air at beginning of compression	0·0625	0·07	0·07	0·07	0·0625
Limiting lb. calorie/cub. ft. $\frac{(57)\,D}{0·0808}$	44	49	49	49	44

TABLE IV.—*Thermal Value Achieved in the Engines.*

Heat in fuel supplied per minute, lb.-calorie	96,100·0	80,650·0	204,800·0	196,000·0	76,250·0
Suction displacement per minute, cub. ft.	38,150·0	3,160·0	6,990·0	7,650·0	3,279·0
Lb.-calorie/cub. ft.	25·2	25·5	29·3	25·6	23·25
Ratio	0·57	0·52	0·6	0·52	0·5

TABLE V.—*Comparison of Power-weight Ratios.*

Weight, tons	822	668	665	705	561
B.H.P., full, A	1,188	1,271	2,910	2,760	1,018
B.H.P., per ton	1·45	1·9	4·4	3·78	* 1·8

TABLE VI.—*Comparison of Power-volume Ratios.*

Cylinder volume, cub. ft.	10·396	6·48	20·22	14·56	8·72
Number of cylinders	6	4	4	6	6
Total volume, cub. ft.	62·4	25·92	80·88	87·36	52·32
I.H.P., A, full	1,527	1,290	3,330	3,360	1,530
I.H.P./cub. ft.	24·5	49·8	41·0	38·5	29·2
Speed, R.P.M.	125	120	87	86	125
Cub. in./I.H.P.	70	35	42	38	29

TABLE VII.—*Comparison of Thermal Efficiencies.*‡

Experiment No.	A 5	A 10	A 13	A 9	A 10
Thermal efficiency on B.H.P. basis	0·291	0·037	0·335	0·332	0·315
I.H.P. basis	0·375	0·405	0·383	0·409	0·48*
Oil per B.H.P.-hour, lb.	0·452	0·353	0·416	0·402	0·422
Oil per I.H.P.-hour, lb.	0·352	0·322	0·360	0·325	0·28†

‡ These are plotted in Fig. 7.
* Probably too high. † This is probably too low.

* Summary of a paper read by Professor W. E. Dalby before the Spring Meeting of the Institution of Naval Architects on Thursday, April 7th.

It will be seen that the Still engine of the motor vessel Dolius gives the biggest return on power for oil input. In order to take into account the power of the engine which was used for driving the steam distributing valves and to allow for the power supplied to the rotary blower, a dotted line based on adjusted values of oil per minute has been drawn. It may be noted that this correction does not alter materially the relative position of the B.H.P. curve for the Still engine. The utilisation of the heat received from the exhaust gases and the cylinder jackets increases the output of the engine for a given input of oil. It is interesting to compare the curves for the Fullagar and Doxford engines as they are both opposed-piston engines and work on the two-stroke cycle. It would appear that there is little to choose between the two results, as both engines give equal outputs of power for equal inputs of fuel oil. From the same curves it is also seen that the Fullagar engine has a slight advantage over the Doxford engine at the higher powers, while at the lower powers the conditions are reversed. In the main both engines show to a better advantage compared with the four-stroke cycle engines which were installed in the motor vessels Cape York and Sycamore. The line for the Cape York engine falls into a mean position between the other lines, but at first it follows very closely the line of the Doxford engine. In making this comparison it has to be borne in mind that the four-stroke engines are comparatively small in relation to the two-stroke engines which were tested.

The curves in Fig. 7 show the mechanical efficiencies of the various engines—which are calculated from the measured I.H.P. and B.H.P. of the "A" full-load and half-load trials—thermal efficiencies and oil consumptions. Table I. represents adjusted figures, the mechanical efficiencies calculated from the measured I.H.P. and B.H.P. after subtracting from the I.H.P. the work done against such auxiliaries as scavenge pumps, compressors, and the like. A point of interest is the remarkable efficiencies achieved by the two-stroke cycle engines. It should be borne in mind that the Cape York efficiencies are in reality probably higher than those given by the figures in Table I.

An important part of the paper is that which deals with combustion and a review of the combustion process. It is assumed by the author that the fuels used in the trials contain about 84 per cent. of carbon and 12 per cent. of hydrogen, which is equivalent to 84/12, or 7 molecules of carbon and 12/2, or 6 molecules of hydrogen. The oils are assumed to be composed of fuel molecules of the form C_7H_{12}. As impurities are shown by analysis to be less than one-tenth of a molecule, they can be neglected. The equation for the correct mixture, assuming the molecular constitution above and neglecting the fractional molecules N_2, O_2 and S_2, is $C_7H_{12} + 10\,O_2 + 37{\cdot}6\,N_2 = 7\,CO_2 + 6\,H_2O + 37{\cdot}6\,N_2$. Thus a mixture of 49 molecules explodes to a mixture of 51 molecules. It is then shown from a consideration of the lower calorific value of the fuel that each individual molecule of oxygen which loses its identity in the combustion process produces on the average 102,372 lb.-calories of heat energy in the mixture. The theoretical air required per pound of fuel and the theoretical higher and lower calorific values are next calculated and are shown to agree substantially with the actual values measured. The comparison seems to indicate that 100,000 pound-calories lower value per molecule of oxygen utilised to produce CO_2 and H_2O is a useful approximation for any oil when making general calculations.

From a consideration of the heat energy of the mixture and the products an upper limit of 57 pound-calories per cubic foot (90 B.Th.U.) is established. It is shown that this value is impossible in practice owing to the actual suction temperatures and pressures. The standard for the comparison of the mixture strength is adjusted to the probable air densities determined in the paper and the thermal value of a cubic foot of cylinder volume for the various engines is given in Table III., while Table IV. shows the thermal value achieved in the engines.

The power-weight ratios of the engines are compared in Table V. The weight given in the first line represents the total weight of main engines and auxiliaries, including spare propeller and tail end shaft. The other items such as water in reserve tank, &c., are excluded on the ground of possible variability. In Table VI. the power-volume ratios are compared, the first line showing the volume per cylinder and the third line the total displacement volume. The thermal efficiencies as calculated by the Committee for the full-load "A" trials are shown in Table VII. Fig. 9 gives a comparison of the terminal and mean pressures and the maximum compression pressure and final pressures in the cylinders. It is noted that with a low-compression pressure the two-cycle Doxford engine in the Pacific Trader shows a maximum pressure nearly as high as a four-stroke engine. The maximum cylinder pressures for all the engines reviewed would appear to be generally about six times the mean pressure. In concluding the paper, the author discusses the air standard and shows by references to the work of recent investigators that the creation of an ideal standard to replace the air standard is a work beset with considerable difficulties.

An Adjustable Cabin Ventilating Fitting.

We recently inspected at the works of John Gibbs and Son, Ltd., of Liverpool, a new type of adjustable cabin ventilator fitting of the firm's newly patented "Ezyreg" design, which has lately been placed on the market. The fitting differs in principle from other ventilators we have seen, in that not only can the direction of the air current be varied within wide limits, but also the amount of air delivered can be regulated from zero up to the full designed output of the ventilator. In the accompanying illustration we show an "Ezyreg" fitting of the bulkhead type. It consists essentially of a brass base, within which the air valve composed of a series of slots which are opened and closed by a sliding plate is housed. The slide is moved by a control wire enclosed in a tube and operated by a switch handle. Above the base of the fitting—which generally has a diameter of about 5¼in.—a spherical dome is fitted, which in turn is provided with an air discharge aperture of about 2¼in. in diameter. The dome is so mounted that it can be moved in a radial direction by the small handle attached to it, and shown opposite the aperture at the lower part of the dome. By such a movement the direction of the air current can be deflected as required. The apparatus shown has a designed output of 60 cubic feet of air per minute when connected to the air trunking and supplied with air at the required pressure. With such an output one such fitting would completely change the air content of an ordinary two-berth cabin once in every five minutes, and usually two such fittings are employed. The slide to which we have already referred so controls the velocity of the air discharged that the air current can be felt up to distances of 6ft. to 7ft. from the fitting, according to the degree of opening given by the regulating handle. In another type of fitting the handle operating the air slide was attached directly to it,

ADJUSTABLE CABIN VENTILATOR

only projecting a convenient distance from the base of the fitting. Ventilating fittings of the types referred to are made in various decorative designs for passenger ship state-room and cabin use.

South African Engineering Notes.

Cape Town Water Supply.

The second instalment of the Steenbras water supply scheme, for the purpose of increasing the supply of water to the City of Cape Town to 15,000,000 gallons per diem, is now in course of construction, and, when completed, will store 6,424,000,000 gallons.

Prior to 1918 the City's water supply was entirely derived from reservoirs constructed on Table Mountain and the Muizenberg Reservoir on the Muizenberg Mountain. By 1917 it was quite evident, however, that a much larger water supply was required, and that it was needed quickly. In 1918 work began on the Steenbras Dam, among the Hottentots Holland Mountains. The dam as built was 900ft. long, 62ft. high and 38ft. wide at the base. The storage capacity was estimated at 600 million gallons, and it actually held 655 million gallons. A 2ft. addition to the height brought the storage up to 784 million gallons. The work of building the dam, the half mile tunnel through the Hottentots Holland Mountains and the laying of the pipe line was taken over from the contractor in its early stages and carried out by the City Engineer's Department. There are 40 miles of cast iron piping leading from the mountain slopes above Gordons Bay to the lower service and Molteno Reservoirs at Cape Town. The internal diameter of the pipes is 30in., each weighs about 2 tons, and the total weight of the whole line amounts to 33,802 tons. The total cost of the first instalment of the Steenbras scheme was £1,180,000. The total amount spent on waterworks—including the Table Mountain and Muizenberg Reservoirs and the service reservoirs and their pipes, and also including the Steenbras scheme—up to the end of 1925 was £3,462,000.

By the second instalment of work commenced in 1924, the existing Steenbras Dam is being raised by 40ft. to 102ft., and its length increased from 900ft. to 1300ft. The thickness at the base is 68ft. The amount of concrete required for these operations is 56,000 cubic yards. The enlarged reservoir, which will be filled next winter, will impound 6,424,000,000 gallons. It will be over four miles in length and nearly one mile in width. The water area will be 827 acres, and the maximum depth of water 90ft.

The second pipe line will follow the line of the first for most of the way and a shorter route afterwards. It will be 34 miles in length and 33in. diameter steel pipes, cement lined on the inside and wrapped with hessian soaked in bitumen on the outside, have been adopted. The length of each pipe is 26ft. 3in. and the finished internal diameter 32in. Each pipe weighs about 3¼ tons, and costs about £60 unlaid. The total number of pipes required for the scheme is 6807 and 405 specials will be employed. The total weight of the new pipe line will be 22,122 tons. The total cost of the first instalment added to the estimated cost of the second instalment gives a total of 2¼ millions sterling for an average daily supply of 15 million gallons. It is anticipated that the third instalment of the Steenbras scheme will not be required until 1936. It will consist of the third pipe line and will probably cost about the same figure as the second, *i.e.*, £750,000. Therefore the total cost of the completed Steenbras scheme will be about three million sterling, for the ultimate supply of 20 million gallons per day.

The limit of yield of the catchment area in a dry year is 20 million gallons per day, and the average daily summer evaporation is 1,200,000 gallons. One advantage of the new steel pipes over the cast iron ones is that, although they are only 2in. more in diameter, they will deliver twice the quantity of water in Cape Town, owing to their greater strength, which allows of the break pressure tank being so much higher up the mountain. The result of that is that the increased height will be that the working pressure will be about 300 lb. per square inch.

Johannesburg Gasworks.

The gasworks expert, Mr. W. H. Herring, who was brought out by the Johannesburg Municipality, to advise upon the tenders received for the erection and equipment of a new gasworks for the city, has reported that the three best tenders are as follows:—(1) The West Gas Improvement Company, Ltd., £161,121 3s. 10d.; (2) Drakes, Ltd., £180,822, and Woodall, Duckham and Co., Ltd., £185,918. All the firms are English. "These totals," Mr. Herring states, "include £5000 contingency expenditure and are based on the assumption that after my return to England I can confirm from specific inquiries that the substitution of concrete for the cast iron tanks of the purifiers and the rotary in place of the drum type of meter is advisable." Otherwise, he states, the tenders will stand in the following order:—(1) The West Gas Improvement Company, Ltd., £169,170 3s. 10d.; (2) Drakes, Ltd., £186,778, and Woodall, Duckham and Co., Ltd., £194,928. Mr. Herring, in conclusion, recommends that Messrs. The West Gas Improvement Company, Ltd., be offered the contract, subject to the terms of the general conditions of contract being complied with. All parties concerned have made provision for using local materials to the largest possible extent. The West Gas Improvement Company is to obtain the major portion of the structural steel work from Gilbert, Hamer and Co., of Durban, and the major portion of the cast iron is to be produced in Johannesburg. The foundation and building work will necessarily be entirely of local production, and certain portions of the structural steel work, by Mr. A. Stewart, of Germiston. The whole of the common bricks will be of local production, and 60 per cent. of the fire-clay bricks will be of Boksburg manufacture.

Three-cylinder Locomotives.

The Union Railways Administration has recently placed an order with Henschel und Sohn, Germany, for two three-cylinder experimental main line locomotives. These locomotives will have a 2–10–2 wheel arrangement, and will be capable of exerting a maximum tractive effort of 53,200 lb. As the most powerful non-articulated steam locomotive in service on the Union railways to-day has a draw-bar pull of 40,744 lb., the new locomotives will represent a considerable advance in tractive effort. Three single-expansion cylinders will be employed, those outside the frame driving the third pair of coupled wheels, while the inside cylinder will drive the second pair by means of a balanced crank axle. The frames will be of the bar type, and to ease the negotiation of curves a special articulated arrangement is being provided at the front end of the locomotives. Other features will include self-cleaning smoke-boxes, mechanical stokers, steel fire-boxes, with arch tubes to support the brick arch. "Franklin" automatic fire-hole door, top water-feed and grease lubrication, a form of lubrication which was first introduced on the Union railways with the advent of the "Karroo" and "Mountain" types of locomotives in 1925. The leading dimensions of the locomotives will be as follows:—Cylinders, diameter 22in.; stroke, 28in.; wheels, coupled, diameter, 4ft. 9in.; wheels, leading truck, diameter, 2ft. 6in.; wheels, trailing truck, diameter, 2ft. 9in.; rigid wheel base, 15ft. 9in.; total wheel base, 38ft. 2¼in.; boiler, diameter inside at front, 6ft. 2¼in.; boiler, length between tube plates, 21ft.; boiler, height of centre from rail, 8ft. 2in.; boiler, pressure, 200 lb. per square inch; grate area, 56 square feet; heating surface, fire-box 258 square feet, tubes 2942 square feet, superheater 828 square feet. The tenders in appearance are not unlike those introduced with the 'Karroo" and "Mountain" types of locomotives. The water capacity will be 6000 Imperial gallons and the fuel capacity 14 tons. In working order the engine and tender together will weigh 206 short tons. On arrival the new locomotives will be put to work in the first instance on hauling mineral traffic on the Witbank–Germiston line. The single train load they will be called upon to convey will be in the neighbourhood of 1850 tons.

Manganese for America.

For some time it has been known that an American steel corporation has been negotiating to acquire the great manganese deposits in the Postmasburg district of the Transvaal. It has now been officially announced by Government that the negotiations have been successfully carried through. The American firm is advancing the sum of money necessary to build a branch line to serve the Postmasburg area. The Union Government will build the railway and will pay a reasonable rate of interest on the money provided for the construction of the line, which will be an important factor in developing not only the mineral deposits of the area, but also its agricultural production. The magnitude of the American enterprise is indicated by the fact that it is expected that thirteen trains daily will be required to deal with the product of the manganese mines alone. Apart from manganese there are other minerals to be exploited, but the Minister declined to specify what other developments could be expected, explaining that a number of propositions were under consideration, but that negotiations had not yet emerged from the confidential stage.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Easter Vacation.

THE approach of the Easter holidays has made poor business poorer. This week, very little material has changed hands, and hardly any interest was displayed in the weekly meeting of the Midland iron trade in Birmingham to-day—Thursday. Last week's quarterly meeting was so disappointing in character that iron and steelmasters hereabouts are becoming pessimistic as to the future of the industry. Any real reinvigoration they say can hardly be expected while production costs remain at the present high level. It is evident that consumers of iron and steel are determined not to buy at present prices, and the slight reductions which have been made in some classes of materials have stimulated business scarcely at all. Consumptive demand seems to have lost its impetus possibly owing to lack of confidence in many departments of trade. Until that can be reinspired, forward contracting is not to be expected, and, while buying remains on hand-to-mouth lines, market vitality is impossible. Ever since the coal strike ended four months ago the market has been striving after a new equilibrium without avail. It is abundantly recognised that trade prospects in many of the engineering and other heavy industries of the Midlands are gradually improving, and producers of raw and finished materials, realising that progress can only materialise if iron and steel can be sold at prices which will enable manufacturers to produce at a profit, have been eager to find a satisfactory selling basis but increased railway rates and high fuel costs have so far frustrated all their efforts, and it is held that only a break in fuel prices can relieve the situation. How long the coal and coke interests will be able to maintain their present basis is problematical. It is, of course, within the bounds of possibility that consumers of iron and steel, who are now holding off the market for lower prices, may be forced by a conjunction of circumstances to buy before long. Any trade stimulus thus brought about, however, would not be lasting for even the lower prices which prevailed a year ago were too high to admit of a permanent revival and expansion of trade. It is earnestly hoped that before next quarter day the situation will have improved and some progress have been made towards establishing a market level which will restore confidence and put an end to the persistant abstention from buying.

Steel Price Cuts.

There are now definite signs of a break in prices of light constructional steel materials. Last week I mentioned that, for forward contracts, lower prices were being accepted for angles, while hoops had been officially reduced 10s. per ton. This week there has been a fall of 5s. per ton in small steel bars bringing them to £15 10s., while ship, bridge and tank plates have declined by a similar amount, making the new minimum £8 7s. 6d. There are, of course, some producers who will not accept these prices, but the fact that business is now being done at those figures is a significant indication of the trend of the market in that branch. For quick delivery of angles and joists special prices continue to be paid, though, as arrears of work at the mills are being rapidly overtaken, and deliveries can be given fairly promptly, buyers are becoming less inclined to pay the heavy premiums asked by makers for early accommodation. Midland constructional engineers find business rather dull and not opening out as it usually does at this time of the year. The call for shipbuilding materials is steadily improving, and the prospects in engineering are considered more promising. There is very little being done in billets. Local sellers still quote £7 as a minimum. Continental billet prices have eased further this week, being obtainable at £5 9s., while blooms are offered at £5 5s.

Raw Iron.

There is no change to record in the pig iron situation. Conditions are most unsettled, and there appears little likelihood at the moment of any relief from the main quarter, that of fuel costs. Blast-furnacemen are still called upon to pay the full 22s. per ton at ovens for furnace coke. Demand for iron is small, and it is an open question whether all the blast-furnaces now active—they are more numerous than a year ago—will be kept at work. Unless demand improves it looks very much as though some, at any rate, will have to be damped down. True, many of the pig consuming industries, such as the pipe foundries, have big contracts on hand, but there is not much pressure at the heavy engineering foundries, and they, like the light castings concerns, are buying pig iron only in small quantities. Midland producers' quotations are officially unchanged. Derbyshire foundry numbers are firm on the basis of £4 2s, 6d. for No. 3. It would have to be a tempting offer to induce sellers to depart from this level. Northamptonshire houses are scarcely so successful in withstanding the pressure applied by prospective buyers. The quotation is £4, but some smelters accept £3 19s. for good sized lots. Forge qualities are, at the moment, the subject of little, if any, attention, and the price sellers would be prepared to accept is under the circumstances unknown. On 'Change in Birmingham to-day sellers of Lincolnshire basic were not averse from negotiation, and the quotation of £4 did not necessarily represent the figure at which business could be done. East Coast hematite sold at quite a shilling lower than a week ago.

Coke Values Upheld.

Blast-furnace coke values are upheld. Midland manufacturers who were hoping for a break gave a certain amount of credence to a recent rumour that the advance of 2s. per ton on contract rates was not being enforced have been disillusioned. The Association which controls the price of blast-furnace coke, and which represents all the chief coke-makers in Yorkshire, Derbyshire, Nottingham, and North Staffordshire, is maintaining its price of 22s. per ton at the ovens for three or six months' contracts from April 1st, or 21s. per ton for twelve months' contracts. Other classes of industrial fuel are now at, or near, pre-stoppage rates, and with intensified competition for turnover, the initiative is being transfrered to the consumer.

Finished Iron.

Outside marked bars, and special iron for the chain and cable industry, the call for finished iron is small and spasmodic. Staffordshire mills experience no difficulty in obtaining for marked bars the basic rate of £14 10s., which has been in operation during the whole of the past quarter. Makers quite fairly point out that they acted with restraint when costs were going up. The deterioration in Crown and common qualities, however, continues. The former are now generally quoted £11 7s .6d. or more than 20s. less than in January. Many mills, however, are shading this figure, but there does not appear to be much response to offers of supplies at £11 5s. An exceptional case is reported of buying at £11. The quotation of £10 7s. 6d. for nut and bolt and fencing bars is nominal. Buying is on restricted lines, and most of the orders go to Belgian houses. The iron strip trade is slow, some of the Midland tube mills working irregularly. Purchases can be made at from £12 10s. to £12 15s. The former figure is the same as the rate prevailing twelve months ago.

Galvanised Sheets.

As a result of increased inquiries from overseas, chiefly from India and the Far East, the galvanised sheet industry is better occupied than has been the case during the past two months. Prices have fluctuated a good deal of late, and galvanised corrugated sheets of 24-gauge, which were recently obtainable at £15 per ton have advanced. They appear to have settled now at £15 5s. This amount is, however, 15s. below the quotation current three months ago when the industry was experiencing something in the nature of boom conditions.

Tinned Sheet Prices.

The Staffordshire Tinned Sheet Association which reports only moderately good business, the general trade depression having reacted on demand of late, has fixed prices for the quarter as follows:—Best charcoal, £58; charcoal, £56; unassorted, £52 per ton to 20-gauge. Lead-coated sheets remain at £28 per ton.

Edge Tools.

The heavy edge tool industry in the Midlands and Staffordshire continues to find business disappointing, and there is considerable unemployed plant. Some improvement is reported in the South and Central American market, but from the Australasian and East and West African areas demand is poor. The usual seasonal activity emanating from the Eastern markets has been conspicuously absent. Orders which are coming through for plantation requirements are for small mixed quantities, showing that the merchants are not buying for stock, as is customary, but only against orders booked. This is attributed to the general unsettlement arising from the Chinese trouble. In India, too, the market has not responded as much as it should under normal conditions, and German competition right through the East has become more pronounced.

Unemployment.

Again this week the Midland trade record, as viewed from the unemployed statistics, is unsatisfactory. In my last letter I had to record an increase of 14,541 in the number of unemployed persons in the area. The latest returns adds a further 6867 to the total, which is now brought up to 155,448. In the Birmingham area the position shows improvement, the total having fallen from 27,182 to 24,425. At Coventry also there has been a decrease, the total being 1742, against 1960. The increase has occurred in the following areas:—Bilston, Cradley Heath, Leamington and Warwick, Leicester, Stoke-on-Trent and Walsall.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

Electrical Contract Goes Abroad.

A DECISION of the Manchester City Council to place a contract for a 1500-kilowatt converter, with switchgear, with a Belgian concern has created a wave of interest that has extended far outside the city boundaries. From the point of view of value the contract is not a substantial one, and it is less the actual placing of the order with a continental firm than the allegations regarding the operations of "rings" in the electrical engineering industry that has aroused discussion. In recommending that the tender of the Ateliers de Construction Electriques, of Charleroi, amounting to £4030, should be accepted, Alderman Dagnall, the chairman of the Electricity Committee, said that in addition to the Belgian offer, the Committee had had three tenders from British firms for the same specification, all within £1 of each other—the lowest being £5045 6s., and the others £5045 10s., and £5046. The Electricity Committee, according to the chairman, urged the acceptance of the Belgian tender because there was undoubtedly a ring among manufacturers, and in the hope that the next time tenders were invited they would not have the competition of the ring as they had at present. They did not want artificial prices forced upon them by agreement among the manufacturers. A request that the names of the British firms concerned should be published in the Press was withdrawn on an appeal by the Lord Mayor and others, on the grounds that such a course might prejudice the firms in competing abroad.

The Case for the "Ring."

As already indicated, the step taken has aroused much discussion, most of it being in support of the City Council. The case for the British tenderers has, however, been put forward by a director of the British Electrical and Allied Manufacturers' Association. It was admitted as being in accordance with the facts that there are so-called "rings" in the electrical industry, but it was pointed out that these were formed to fight similar organisations on the Continent, and that every order that went abroad helped to increase the power of the continental rings and so damage the British electrical industry. An examination of the balance sheets of the British firms for the past few years would show that the average profit made by them was in the neighbourhood of 5 per cent.; some made 6 or 7 per cent., but that was the highest. Prices had been cut by the home manufacturers to the lowest possible limit, but the lower they cut the lower were the quotations of firms included in the continental ring. The reason why the latter were able to do this was that production costs on the Continent were much lower than here, labour was much cheaper, and working hours were longer.

Textile Machinists' Prospects.

A week ago reference was made in this column to the approaching completion by Lancashire manufacturers of textile machinery of the large contracts placed by the Russian Textile Syndicate towards the end of 1925. Acute depression has been the lot of the textile industry in this country for several years, and that condition, though less pronounced, still obtains. The fact that most of the cotton mills in this area are closed all the present week until after the Easter holiday in order to avoid the accumulation of excessive stocks, is sufficiently indicative of the present situation. The natural consequence has been, and still is, that orders for new textile machinery for the domestic industry has been very poor indeed. Orders from abroad have also been limited during recent months, with the result that few firms engaged in this branch of engineering are working full time. I referred recently to the prospect of further substantial contracts for Russia. It would appear that the likelihood of them has by no means faded away. A programme drawn up to cover requirements during the next five years embraces large quantities of textile plant. Longer credits than those provided for under the previous contracts have been the principal difficulty, but the prospects for a solution of this are good, and North of England firms are likely to benefit from the additional orders which, it is now expected, will be placed before long. Cotton manufacturing developments in Australia also promise work for Lancashire textile machinists in the near future. The Lancashire cotton firm of James Nelson, Ltd., is completing arrangements for the erection of two mills in Australia, and it is probable that the orders for the necessary equipment will be placed here. Australia is among the smallest overseas markets for British textile plant, but is a steadily growing one, last year's shipments thence amounting to over £310,000, or an increase of more than £50,000 since 1924.

Non-ferrous Metals.

All sections of the market in non-ferrous metals have participated in the general decline in values that has taken place since last report, tin, as is not unusual, being the most conspicuous. Following a spurt early on, due to external factors, the tin market suffered a relapse compared with the prices current at the time of last writing to the extent of about £5 10s. per ton in the case of spot metal, the fall in the forward position, however, being much less pronounced, the difference on balance being about £2 10s. Buying for industrial consumption, as distinct from speculative purchases, is only on a moderate scale and the increase in domestic stocks tends to have a bearish influence on prices. A relatively important decline has also taken place in the case of copper, to some extent in sympathy with the United States market, although the rather quiet demand from users and the trouble in China have also had their effect. Up to the present there has been no improvement in buying interest in either lead or spelter, and values in each case have reacted in consequence. Fluctuations have not, however, been violent, and the difference on the week is no more than on the scale that one usually meets with in the ups and downs of these metals.

Iron.

Except perhaps for a condition of rather more pronounced quietness normally experienced on the eve of a holiday break, there has been no striking development on the Lancashire market for pig iron and manufactured iron. The important feature still is that the demand is on unsatisfactory lines, and the persistent holding off of buyers is naturally having a weakening influence on the market. There is, however, little actual alteration in current values compared with a week ago, although there is no disguising the fact that the position is anything but strong. For Midland brands of pig iron—Derbyshire and Staffordshire—parcels could be bought at from 88s. to 90s. per ton, delivered into this area, with Middlesbrough makes on the same basis at 92s. 6d., Scottish at about 103s., and hematite at 96s. The weak feeling, in spite of the high prices that are being paid for blast-furnace coke, is eloquent enough of the state of trade in this section of the iron and steel markets. The demand for finished iron is also extremely unsatisfactory, with Lancashire Crown bars on offer at £11 per ton and seconds at £10.

Steel.

More and more steel makers apparently are now feeling the effects of the persistently sluggish flow of new orders since the beginning of the year, and, judging from the tone of the market during the week, plate rollers are the ones most seriously affected. About £8 7s. 6d. per ton—the Association minimum price—is now the more usual quotation for ship and tank plates, although some firms who, until quite recently, were holding fast to £8 15s., are still asking £8 10s. or £8 12s. 6d. There is rather greater steadiness in the case of joists, which are

still at 2s. 6d. to 5s. per ton, according to delivery, above the minimum of £7 12s. 6d., the order books in the case of these being somewhat more favourable. No change can yet be reported in basic steel bars, and about £9 per ton is still being asked. Boiler plates are currently quoted at from £11 7s. 6d. to £11 10s. per ton. There is very little business passing in small re-rolled bars, which are on offer at £8 10s. per ton. The demand for continental steel remains poor and values have eased off again, billets being quoted now at about £5 5s. per ton, sheet bars at £5 10s. to £5 12s. 6d., sections at £6 2s. 6d. to £6 5s. ordinary plates at £7 2s. 6d., Siemens plates at £7 7s. 6d., and steel bars at £5 17s. 6d. to £6 per ton, delivered to users' works in the Lancashire district, for cash against shipping documents. Galvanised sheets are slightly steadier at about £15 per ton for 24 gauges, but there has been no improvement in the demand.

Scrap.

Buying of non-ferrous metal scrap has continued on a quiet scale, but prices keep fairly steady at £73 per ton for cast aluminium, £45 for heavy yellow brass, £57 for clean light copper, £25 10s. for zinc, £27 for lead, and £52 for selected gunmetal, in all cases for properly graded qualities and including delivery to users' works.

Barrow-in-Furness.

Hematite.

Makers continue to be busy on deliveries which are still maintained and are likely to be for some time yet. Orders, except for immediate delivery, are still scarce, consumers waiting for a possible fall in the price of iron. This fall will not occur until there is a reduction in the cost of coke, which still keeps at its high price. In view of the general outlook in the engineering and shipbuilding trades there seems every chance of trade continuing to be fairly good. Apart for a small overseas trade, the deliveries are fairly heavy all round. The Midlands are taking the heaviest deliveries, but Scotland is a fair customer, and there is a good amount of pig iron going to North and South Wales, mostly coastwise. The demand for higher qualities of pig iron continues to be maintained, and ferro-manganese is experiencing a steady market. The local steel works are taking a proportion of the output of iron at Workington and Barrow, and will continue to do so until such time as the steel orders are exhausted. The iron ore trade remains steady and this remark applies alike to native and foreign sorts. Steel rails, &c., are being turned out at Barrow and Workington, but fresh orders are not coming in as well as one could wish. There has been a dispatch of rails and fish-plates from Barrow for Fremantle. There has also been a dispatch of hoops from the Barrow Hoop Works for Galveston, &c. Much of this material finds its way to the cotton districts of America, and also to Uganda and Kenya. There will be short holidays at the works for Easter. Neither in the iron and steel works, nor the shipbuilding and engineering works, is there a desire to waste much time on holidays at the present moment.

SHEFFIELD.

(From our own Correspondent.)

Absence of New Business.

The feeling in Sheffield with regard to the prospects of steel trade progress does not improve, and is perhaps less cheerful than it has been of late. It was hoped that the quarterly meeting in Birmingham last week would produce signs of a turn in the tide of the iron and steel industries generally, but that hope did not materialise; the meeting being, in fact, a very poor one. We have reached a period of the year when trade movements do not, as a rule, show much upward tendency, and it is now feared that there can be no general revival before the autumn. The big open-hearth plants in this district are still working very busily, but they are approaching the end of their arrears of orders, and makers are getting anxious in consequence of the absence of new business on a substantial scale. None of them can afford to produce for stock, and, unless there is a considerable flow of new orders during the next month, it will probably be necessary to reduce the number of furnaces in operation. There is an increasing call for shipbuilding steel and some classes of engineering requirements, but the demands from the collieries are on a disappointing scale. Although there is a certain amount of axle, tire, and spring work on hand, the bulk is not large, as the railway companies are holding back orders and specifications for the time being.

The Tool Trades.

Sheffield makers of farm tools are enjoying a fair demand for their products, but the season for garden tools is proving one of the poorest experienced for a number of years. In the latter section, competition from Germany is very keen, alike in England and in our export markets. Some extremely cheap lines are being sent out by Germany, the prices being so much below those of British goods that even the preference allowed to this country fails to keep the foreign article out of the Dominions. The depression in the file trade continues. In the branches devoted to saws and engineers' small tools mixed conditions are reported, some makers being fairly busy while others are poorly employed.

Another Electric Crucible Furnace.

In addition to the Ajax-Northrup electric crucible furnace, which is being installed by Edgar Allen and Co., Ltd., as I mentioned last week, I now learn that one is being put down by William Jessop and Sons, Ltd. The furnace consists of a crucible which, in the case of a 6-cwt. size, is of 15in. internal diameter and 24in. high, surrounded by a copper coil which carries the current. The space between the coil and crucible is packed with heat-insulating material. The standard furnace is of the nose-tilting type. The furnace is attracting much interest in Sheffield. A number of steel firms have sent their experts to study its working, and some of them are desirous of adopting it, but financial considerations are a handicap in these days, as the expense of installation is rather heavy.

Cutlery and Plate.

Little improvement is to be recorded in the cutlery and plate trades. The general home demand is poor, the amount of business done through the ordinary shopkeeping channels being of a disappointing character. Special orders from public caterers continue to provide a valuable amount of work, and rather more business is coming forward from the Dominions. In the main, however, the trades are depressed, and some large firms have been doing badly all this year. The grinding conditions in the city are being gradually reformed, and one new establishment designed on up-to-date lines is in course of erection. Artificial stones are coming more and more into use for table blade grinding. In the past, it has been difficult to obtain these stones of the proper grit and texture for the work; but it is reported that it is now possible to grind the blades satisfactorily on the newer type of wheel, although sandstones are used for the subsequent whettening process. The stones are expensive, and this factor is proving an obstacle to their general use. Artificial stones are now used to a large extent for the grinding of pocket-knife blades.

New Auto-car for Railways.

The Sentinel Steam Wagon Company has recently produced a steam rail coach of a new type, which had been put into railway service in the South of England, and it is now likely to be adopted in the North, as a result of trials which were made by the L.N.E.R. Company last week. The car was tried between York, Malton, Whitby, Scarborough, and Robin Hood's Bay, a part of the line which has heavy gradients and many curves, and it came through the experiment very satisfactorily. The car is 56ft. 4in. long, and stands 12ft. 6in. high from the rail level, its internal height being 8ft. It has a seating capacity of sixty-five. The Sentinal patented vertical engine is carried in an engine-room, on a four-wheel bogie, which is articulated to the main vehicle. There is a driver's compartment at the rear, so that it is not necessary to turn the vehicle round, and also a guard's and luggage compartment. The car is steam heated and lighted by electricity. The vehicle, including the engine, weighs 25¼ tons. The consumption of coal is only about one-third as much as that of the ordinary locomotive auto-car. The idea is to provide a cheap unit for branch lines and a frequent service, especially in districts where road competition has to be met. It is stated that the car will probably be put into service in the Newcastle area very shortly.

Preheating for Small Boiler Plants.

Mr. Charles F. Wade, of Sheffield, has devised a system of air preheating for use with smaller and medium-sized plants of the Lancashire and other cylindrical types of boiler. Hitherto, the great obstacle to the practical application of air preheating to comparatively small factory boiler plants has been the disproportionate cost of the plant together with the great space occupied and high maintenance costs. Mr. Wade's system consists merely of substituting for the usual fire-brick lining of the side walls of the boiler flues a series of cast iron ducts or recuperators, through which the air for combustion is passed and becomes highly preheated in its passage, the surface of the air ducts being formed with longitudinal fins or corrugations in order to assist in the heat transfer process. The use of this system, it is claimed, makes practicable the efficient employment of all kinds of low grade refuse fuel, if used in conjunction with an improved form of forced draught fire-grate, while the apparatus itself calls for no more space than that originally occupied by the boiler.

The Charles Hawksley Prize.

The Charles Hawksley prize of £150, open for competition to all associate members of the Institution of Civil Engineers up to thirty years of age, has been won, for the second year in succession, by a competitor from Rotherham. This year's winner is Mr. M. E. Habershon. The prize is awarded for the premier design of a specified civil engineering structure of considerable magnitude, and Mr. Habershon's design was for a reinforced concrete viaduct several hundred feet in length. He is a past student of the Civil Engineering Department of Sheffield University, where he graduated with honours in civil engineering in 1920, and obtained his M. Eng. degree in 1921. Last year's successful competitor was Mr. J. W. Husband, who, like Mr. Habershon, is a Rotherham man. Both of them are members of the staff of Major Vincent Turner, M. Inst. C.E., the borough and water engineer of Rotherham. They both received their early training under Professor J. Husband, Professor of Civil Engineering at the University of Sheffield.

The Thousandth Launch.

Cochrane and Sons, Ltd., of the Ouse Shipbuilding Yard, Selby, launched their thousandth vessel one day last week, and followed it immediately with another. The two new craft were steel screw tugs, the Kenia and the Gondia, for Wm. Watkins, Ltd., London. It was pointed out that the first vessels built at Selby, under the present ownership, were also for Messrs. Watkins. Messrs. Cochrane's record includes the building of 700 trawlers, 81 mine-sweepers, 63 drifters, 33 tugs, 29 coasters 8 petrol gunboats, and other craft.

NORTH OF ENGLAND.

(From our own Correspondent.)

Trade and Holidays.

The quietness which has characterised most sections of trade during the past two or three weeks has been accentuated this week by the approach of the Easter holidays, and the general trade position presents no new features. There will be no interruption at the ironworks, but operations at the steel works will be suspended on Monday and Tuesday.

Cleveland Iron Trade.

Although Cleveland pig iron producers are fairly well situated at the moment as regards orders on their books, they are viewing the future with some amount of apprehension. The fact is that business is not coming forward in the volume anticipated to ensure continuity of operations at the blast-furnaces. They have been largely engaged during the past three months in supplying the needs of their own and other steel works and in overtaking arrears of delivery under old contracts, but these commitments are being rapidly worked off, and in the course of a few weeks it is expected that there will be a big surplus of iron for the open market. There are now forty-six blast-furnaces operating on the North-East Coast, and the disposal of the surplus output is likely to be a matter of great concern. Contending that prices are still too high, consumers adopt a very cautious policy, and are only placing orders for small quantities to cover immediate needs. Ironmasters, however, are not yet disposed to make any further concessions. Fuel is certainly cheaper, but conditions are unstable, and probably they want to be assured of still cheaper supplies before any further reduction is made in their selling prices. Market rates are as follows:—No. 1 foundry, 82s. 6d.; No. 3 G.M.B. Cleveland, 80s.; No. 4 foundry, 79s.; and No. 4 forge, 78s. 6d. per ton.

Hematite Pig Iron.

Notwithstanding the complaint of producers that East Coast hematite iron prices have sunk well below cost of output, the downward movement continues. Makers have to contend with keen competition from West Coast and continental producers, and are anxious to enter into contracts so as to keep their blast-furnaces in operation. Rumours are current that firms may be compelled to put furnaces out of blast if the downward movement is not checked, and if the working expenses do not cheapen. East Coast mixed numbers are quoted at 84s. per ton, but business is stated to be possible at 83s.

Iron-making Materials.

The foreign ore trade is again dull and featureless after the recent spurt. Long contracts of a very substantial character are the rule in this trade, but most consumers are now well placed, and new business is confined to an odd cargo or so. Best Rubio ore is nominal at 22s. per ton, c.i.f. Tees. Prices of Durham blast-furnace coke are gradually falling, but users contend that they are still too high. Good medium qualities are quoted 24s. per ton delivered at the works, and purchases are reported to have been made at below that figure.

Manufactured Iron and Steel.

Finished iron and steel manufacturers are well sold over the next few months, but orders are not being placed anything like so quickly as they are being cleared off. The wagon shortage, which has handicapped the trade for some time past, has now been overcome, and the supply is regarded as satisfactory. At one of the works last week over 6000 tons of steel were removed. Steel prices are not quotably altered, though it is reported that in odd cases concessions have been secured for attractive specifications.

Ironstone Miners' Wage Cut.

A decrease of 5 per cent., on the base rates of Cleveland miners' wages was decided upon at a meeting of the mineowners and men's representatives on Monday. The employers had made out a case in favour of a decrease under the sliding scale of 11·6 per cent. The reduction will come into operation at the end of this month. An increase in the base rates of mechanics employed at the mines of 4d. per shift was granted. This carries with it district percentage, and means a considerable amount to the mechanics.

The Coal Trade.

There is no apparent improvement in any section of the Northern coal trade. Some continental countries like Belgium are producing more fuel than they can get rid of, and Germany is keenly competing for business at low prices. There seems to be much more coal on offer in Europe at the moment than competitive demands require. Thus, a very quiet tone is experienced on the Northern market. Merchants have covered their limited requirements for over the holidays, and whether the position will brighten up after Easter no one can tell. Low prices for large Northumberland steam coal have had scarcely any effect in bringing more trade. Hence the oft-repeated assertion at the beginning of the year that reduced quotations would attract business has not proved reliable in actual experience. All Northumberlands are dull in tone, and weak in price with the exception of smalls. Supplies offer freely, the few transactions passing being mainly through second-hand holders, by whom slight discount prices are accepted. All large screened steam coals are readily obtainable at 15s. per ton, with second qualities at 14s. 6d. In the Durham market best grades of gas coal have a steadier appearance, although the volume of trade is nothing like what it should be. Best Durham gas coal is quoted 17s. to 17s. 6d., and secondary kinds at 15s. to 15s. 6d. Steams also keep up to late figures, but coking coals and bunkers are in large supply at easy prices. There is a steady inquiry for gas coke, both home and abroad, and prompt prices are very steady at 22s. 6d. to 23s., and for over the year at 23s. Patent cokes are more plentiful, but prices are maintained for good ordinary at 23s. to 25s., and for bests 26s. to 28s. Beehive coke is quiet and nominal at 30s. to 37s. 6d.

Blast-furnacemen's Welcome Advance.

An advance of 9·25 per cent. in the wages of blast-furnacemen on the North-East Coast, which follows upon the ascertained selling price of Cleveland pig iron

for the past quarter, affords a welcome amelioration in the conditions of employment of a body of men who have made great sacrifices to preserve peace in the iron trade, and to hasten the industrial recovery. The latest advance raises the wages from 14·75 to 24 per cent. above the standard. No other section of workmen has made such sacrifices as the blast-furnacemen. It may be recalled that all old agreements between the ironmasters and men were scrapped in November, 1919, and a new contract then made operative, the effect of which was to fix a selling price of 54s. per ton as the standard for the resolving of wages, with every shilling rise or fall in the ascertained selling price of iron over one-quarter equivalent to a rise or fall of 1 per cent. in the men's wages. Abnormal conditions, however, followed shortly afterwards. The pig iron trade became severely depressed, and the number of furnaces operating then was only twenty-two. In view of this development, the men made a concession. Entitled to 57 per cent. on the scale, the men accepted 36 per cent. and in the quarter ending June, 1922, agreed temporarily to recognise an increase in the standard selling price per ton for wage calculation from the fixed rate of 54s. to 61s. 6d. This step was taken in recognition of the perilous state of the industry at the time. Yet a further concession to the ironmasters was made in December, 1923, when the standard temporarily was recognised as 67s. 6d. In the last quarter of 1926 the basis was waived completely. As trade has gradually revealed improvement, masters and men have endeavoured in a commendable spirit to restore the standard fixed by their 1919 agreement. In March, 1925, the 67s. 6d. was reduced to 66s. 6d. From October, 1925, a further reduction became operative. From July, 1926, the standard was reduced again to 57s., and in October, 1926, brought back to the 1919 level of 54s. The agreement therefore has now resumed its normal effect, unaltered by concessions either way. It is to the credit of both contracting parties that mutual difficulties have been faced in a broad-minded, constructive spirit, and that the employers have made every effort gradually to restore the contract, while the men have made important concessions in times of duress.

SCOTLAND.

(From our own Correspondent.)

Miners' Working Hours.

THE Lancashire Miners' Union has endorsed the provisional agreement made between its officials and the Coalowners' Association for the adoption of a uniform working policy of eleven days per fortnight. This agreement is to run concurrently with the wages settlement for a period of three years. The new arrangement does not apply to collieries which were on a six days' week prior to the dispute of last year. West Lothian and Stirlingshire have already approved a similar agreement.

New Business.

It is announced that William Beardmore and Co., Ltd., have secured a contract for wheels and axles worth approximately £50,000 for the South African Railways and Harbours Administration. Messrs. Beardmore also recently secured an order for 7000 tons of rails for the State Railways of Esthonia.

Steel.

The Scottish steel market shows no alteration; many works are very busy on accumulated contracts, but fresh business is still extremely quiet. Makers are pressed for shipbuilding material, and deliveries are in some cases protracted. Home prices are unchanged.

Steel Sheets.

Business in sheets has quietened down somewhat, both for black and galvanised descriptions, buyers evidently awaiting easier prices. Some merchants have been able to secure deliveries of the cheaper qualities at reduced prices, but quotations on the whole are steady, as some makers have still plenty of orders to overtake.

Pig Iron.

The number of furnaces in blast in Scotland is now thirty-four, and this number is not likely to be exceeded meantime. Hematite on occasion is not too plentiful, but foundry qualities are easily obtainable. Prices are fairly steady, but the tendency is weaker.

Bar Iron.

Bar iron makers report that business is not improving, either in iron bars or re-rolled steel bars. All departments are in need of fresh orders. The recent reduction of 10s. per ton in bar iron has been practically unproductive of home business and export orders involve reductions on the existing quotation of £11 5s. per ton for Crown quality iron bars. Re-rolled steel bars are quoted in the vicinity of £8 7s. 6d. per ton, home or export.

Coal.

There are few, if any, bright spots in the Scottish coal market, and the outlook is unpromising. Home demands generally are far below normal. Utilty concerns continue to use considerable quantities of American fuel, stocks of which are still fair. Industrial demands are not expanding as anticipated, while household fuel is dropping off as the season advances. The export department still suffers severely from keen competition from North of England as well as foreign fuels, and exporters experience great difficulty in securing fresh business. Prices of Lanarkshire fuels are barely steady, and Ayrshire descriptions are only a shade better. East of Scotland districts are hardest hit by the absence of export orders, and apart from treble nuts, both in Fifeshire and the Lothians, an easier tendency in prices is apparent.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Conditions.

BUSINESS for shipment round about the holidays was for the most part completed last week, and the result has been that the conditions have quietened down. Most exporters are concentrating their attention on getting steamers loaded and sailed before the vacation, and operations are practically confined to picking up small parcels which may be needed to complete cargoes. Tonnage is, of course, being taken up for loading after the holidays, which, from the point of view of exporters, come at rather an inopportune time, seeing that the loss of the best part of a week's output is sustained right in the middle of the month, thus causing exporters some concern in the case of shipments which have to be made by the end of the month. Once the holidays are past, there will not be a great deal of time to execute commitments unless the tonnage traders are able to secure is ready immediately after the vacation. As a matter of fact, most of the prompt tonnage has already been booked up, and there is a feeling that the market for tonnage is likely to become better after the holidays. This remark applies more particularly to the Mediterranean upper ports, for which there is a good demand. So far as coals for delivery ahead are concerned, there are a few inquiries on the market, and exporters have now received intimation that tenders for 100,000 metric tons of Welsh large coals for the Egyptian State Railways have to be in at Cairo on May 3rd for adjudication on that date. The coals have to be delivered at Alexandria, 10,000 tons during May, 50,000 tons during June, and 40,000 tons during July. The Navagazione Generale Italiana has asked for tenders for five cargoes of about 7000 tons each of superior Welsh large coals for delivery during May, June and July at Buenos Aires, while there is also an inquiry on the market for about 25,000 tons of steam coals for delivery from June onwards at Mauritius. The demand for cargoes for current shipment is for the time being rather on the slow side, but collieries producing the better grades of coal are very fully sold for the remainder of this month. The statement of Sir Thomas Royden that the Cunard Steamship Company may have to revert to coal for a part of its fleet has naturally caused a good deal of interest in this district, and is regarded as an encouraging sign. In the old days the Cunard Company used to take about a million and a-half tons of coal per annum.

Coalfield Items.

Work was resumed about the middle of last week at the Blaenavon Company's pits, where there had been a stoppage since Tuesday of the previous week on account of the action of the workmen in having a show of cards, with a view to compelling the miners there to become members of the South Wales Miners' Federation. Reports are current that the company is prosecuting the men who struck work for breach of contract and loss of output, while it is also stated that the Craftsmen's Union and the new Industrial Union intend suing the Federation for loss of wages. The new Industrial Union is getting into a strong position, as it is now understood that this organisation has a membership of 35,000 miners. Unfortunately, there is just the prospect that coalowners and traders may suffer occasionally by the rivalry between the Industrial Union and the Miners' Federation. The Executive Council of the latter body met at the end of last week to consider what action could be taken to rehabilitate the Federation. A sub-committee was appointed to make arrangements for "showing cards" at the collieries, and the convening of a delegate conference to decide the steps to be taken to bring the organisation back to its former strong position. The adoption of "show cards" at the collieries foreshadows stoppages at the pits which will cause a great deal of inconvenience to shippers and interfere with trade, to say nothing of possible trouble that may arise between the men themselves, owing to their belonging to different organisations. All the pits belonging to the Main Company, with the exception of the Court Herbert Pit, closed down last week, owing to the bad state of trade. These collieries only resumed work last December, after being idle for two years. Hopes are entertained, however, that the present stoppage will only be temporary.

Reported Sale of Swansea Works.

Although no official confirmation or denial is so far forthcoming, it is reported in the Swansea district that the works of Sir W. Arrol and Co., which it was decided to close down recently on account of the bad state of the steel trade, are likely to be acquired by A. D. Dawnay and Sons, of Battersea and Cardiff. Arrol's constructional works are situated at King's Dock, Swansea.

Current Business.

The tone of the steam coal market remains practically unchanged, except that a holiday atmosphere has naturally prevailed. Work at the docks has been very busy during the past week. Considerable loading pressure has existed, as both shipowners and coalowners have done their utmost to get steamers loaded before the vacation, so as to save expense. On Monday there were only seven loading berths idle at the whole of the docks in this district, and some of them were at docks where only small vessels can be accommodated. As against this fact, there were no less than twenty-three steamers waiting their turn to get into berths, so that the chances are that, despite every effort that may be made, many steamers will be compelled to wait until after the holidays to secure their full cargoes. Prices of steam coals have not varied to any appreciable extent, superior qualities being very steady, with inferior descriptions and dry coals somewhat easy and irregular. The feature of the market has been the break in pitwood prices. This market recently touched 40s., but the second half of last week saw a sudden weakness develop, with the result that the price is now about 35s., with the prospect of going still lower for supplies for delivery after the holidays.

The Late Mr. Charles L. Jewell.

Mr. Charles L. Jewell, a member of the firm of Messrs. Jewell and Sons, railway contractors, Barnstaple, died on Friday, April 8th, at the early age of thirty-seven. Prior to his association with his father in the firm, Mr. Jewell was on the engineering staff responsible for the doubling of the London and South-Western Railway Company's permanent way between Copplestone and Umberleigh. On the death of his father, a few years ago, he assumed control of the business. He was a capable business man, and a promising career has been cut short by his untimely death.

CONTRACTS.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., has obtained a twelve months' contract from the City and County Borough of Belfast for the supply of Mazda electric lamps.

THE HAMWORTHY ENGINEERING COMPANY, Ltd., of Poole, Dorset, and 76, Victoria-street, Westminster, S.W. 1, London, has received a further order from Greece for four of its 20 horse-power marine oil engines, each complete with propeller and stern gear.

SIMON-CARVES, Ltd., of 20, Mount-street, Manchester, has received from the County Borough of Wallasey Electricity Department an order for two Simon-Carves water-tube boilers, each designed for a maximum evaporation of 70,000 lb. per hour at 300 lb. per square inch pressure, together with economisers, superheaters, chimneys, grit catchers, induced draught plant, coal bunkers, automatic coal weighers, pulverisers, boiler feed pump, and all the necessary valves and instruments.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MESSRS. BOULT, WADE AND TENNANT, patent agents, of 112, Hatton-garden, London, E.C. 1, ask us to announce that, as from the 1st instant, they have taken into partnership four of their senior technical assistants, Messrs. R. S. Dolleymore, J. C. Rennie, A. Abbey, and T. B. Clerk, all Fellows of the Chartered Institute of Patent Agents. The firm will continue to practise under its present style.

WE are asked to announce that Mr. P. N. Rand, the general sales manager of the Metropolitan-Vickers Electrical Company, Ltd., is severing his connection with that company. He will officially terminate his connection with the company on September 30th next, but will relinquish his active representation about the middle of May. His address thereafter will be c/o Royal Automobile Club, Pall Mall, London.

CATALOGUES.

HIGGS MOTORS, Witton, Birmingham.—List of alternating-current and direct-current industrial electric motors.

HUNT BROTHERS (Oldbury), Ltd., Griffin Foundry, Oldbury.—Brochure illustrating the range of castings produced by the firm.

J. BLAKEBOROUGH AND SONS, Ltd., Brighouse, Yorkshire.—Catalogue No. 100 giving full particulars of all types of valves and auxiliaries for power plants.

THE ENGLISH ELECTRIC COMPANY, Ltd., Queen's House, Kingsway, W.C. 2.—Publication entitled "English Electric Locomotives for Industrial Purposes."

E. T. WHITE and Co. (1926), Ltd., 56, Kingsway, W.C. 2.—Booklet entitled "Modern Aluminium Pistons," the latter part of which gives full particulars of the "Lynite" piston.

THE INCANDESCENT HEAT COMPANY, Ltd., Cornwall-road, Smethwick, Birmingham.—List No. G.H.T. 16 on "Incandescent" furnaces and equipment for heat treatment of all kinds.

THE STEEL BARREL COMPANY, Ltd., Uxbridge, Middlesex.—Latest booklet dealing with wagon tanks giving particulars of various types of tanks made, the method of construction, and the sizes.

SIR WM. ARROL AND CO., Ltd., 59, Palace-street, S.W. 1.—The 1927 edition of the firm's crane and transporter catalogue. The book is divided to show the leading types of cranes manufactured by the firm.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., Rugby.—Publications dealing with: Switchgear for outdoor service; oil-immersed circuit breakers of various types; earthing resistances; alternating-current and direct-current drum controllers and resistances for industrial service.

HADFIELDS, Ltd., Tinsley, Sheffield.—Illustrated descriptive pamphlets:—No. 177, dealing with single-toggle breakers and granulators; No. 182, with the "Hecla" disc crusher; No. 185, with coal breakers; No. 200, with portable stonebreakers and crushers; and No. 217, with revolving screens.

PRESENTATION TO PROFESSOR DEMPSTER SMITH.—At the meeting of the members of the North-Western Branch of the Institution of Mechanical Engineers, held in Manchester on Thursday, 7th inst., Professor Dempster Smith was presented with a gold watch and Mrs. Smith with a diamond ring, both of which had been subscribed for by the members of the branch, as a testimonial to Professor Smith, in recognition of his valuable services as honorary correspondent and afterwards as honorary secretary of the branch. The presentation was made by the chairman of the branch, Mr. Harold F. Massey, who spoke in high terms of the excellent work which Professor Smith had rendered to the Institution for ten years.

FARADAY HOUSE ELECTRICAL ENGINEERING COLLEGE ENTRANCE SCHOLARSHIPS.—As a result of the entrance scholarship examination held at Faraday House Electrical Engineering College on April 5th, 6th, and 7th, the following awards have been made by the Governors of the College:—Maurice V. Ratcliffe, Alleyn's School, Dulwich, the "Faraday" Scholarship of 50 guineas per annum, tenable for two years in college and one year in works; Kenneth B. Blake, Portsmouth Grammar School, the "Maxwell" Scholarship of 50 guineas per annum, tenable for one year in college and one year in works; Rex Hammond, Alleyn's School, Dulwich, an Exhibition of 40 guineas per annum, tenable for one year in college and one year in works; John H. Hovell, King Edward VI. Grammar School, Norwich, an Exhibition of 30 guineas per annum, tenable for one year in college and one year in works; Harry St. G. Gardner, Felstead School, Essex, an Exhibition of 30 guineas per annum, tenable for one year in college and one year in works; Stanley P. Smith, City of London School, an Exhibition of 30 guineas per annum, tenable for one year in college and one year in works; George A. Wallace, Fettes College, Edinburgh, a Special Prize of 20 guineas.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
Native	18/6 to 21/–
(1) Spanish	18/6 to 21/–
(1) N. African	18/6 to 21/–
N.E. Coast—	
Native	18/– to 21/–
Foreign (c.i.f.)	22/–

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) Scotland—		
Hematite	4 5 0 to 4 7 6	
No. 1 Foundry	4 11 6	—
No. 3 Foundry	4 6 6	—
N.E. Coast—		
Hematite Mixed Nos.	4 3 0	4 3 0
No. 1	4 3 6	4 3 6
Cleveland—		
No. 1	4 2 6	4 2 6
Silicious Iron	4 2 6	4 2 6
No. 3 G.M.B.	4 0 0	4 0 0
No. 4 Foundry	3 19 0	3 19 0
No. 4 Forge	3 18 0	3 18 6
Mottled	3 17 6	3 17 6
White	3 17 6	3 17 6
Midlands—		
(3) Staffs.—		
All-mine (Cold Blast)	—	—
North Staffs. Forge	4 0 0	—
,, ,, Foundry	4 7 6	—
(3) Northampton—		
Foundry No. 3	3 19 0 to 4 0 0	
Foundry Forge	3 10 6	—
(3) Derbyshire—		
No. 3 Foundry	4 2 6	—
Forge	3 15 0	—
(3) Lincolnshire—		
No. 3 Foundry	4 1 6	—
No. 4 Forge	—	—
Basic	4 0 0	—
(4) N.W. Coast—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 17 6 (a); 5 0 6 (b); 5 4 0 (c)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Scotland—		
Crown Bars	11 5 0	—
Best	—	—
N.E. Coast—		
Iron Rivets	12 15 0	—
Common Bars	11 15 0	—
Best Bars	12 5 0	—
Lancs.—		
Crown Bars	11 0 0	—
Second Quality Bars	10 0 0	—
Hoops	14 0 0	—
S. Yorks.—		
Crown Bars	11 15 0	—
Best Bars	12 5 0	—
Hoops	14 0 0	—
Midlands—		
Crown Bars	11 5 0	—
Marked Bars (Staffs.)	14 10 0	—
Nut and Bolt Bars	10 7 6	—
Gas Tube Strip	12 10 0 to 12 15 0	

STEEL.

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates	11 0 0	11 0 0
Ship Plates, ½in. and up	8 7 6	£8 0 0 to 8 5 0
Sections	7 17 6	£7 10 0 to 7 15 0
Steel Sheets, under 3/16 in. to ½in.	10 0 0 to 12 0 0	
Sheets (Gal. Cor. 24 B.G.)	—	£15 0 0 to 16 0 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. Coast—		
Ship Plates	8 7 6	—
Angles	7 17 6	—
Boiler Plates	12 10 0	—
Joists	7 17 6	—
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	8 12 6	—
Soft Billets	7 12 6	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 10 0†	—
Light Rails	8 15 0 to 9 0 0	
Billets	8 0 0 to 11 10 0†	
Manchester—		
Bars (Round)	9 0 0	—
,, (Small Round)	8 5 0	—
Hoops (Baling)	11 0 0	11 0 0
,, (Soft Steel)	10 15 0	10 15 0
Plates	8 7 6	—
,, (Lancs. Boiler)	11 7 0	—
Sheffield—		
Siemens Acid Billets	11 0 0	—
Hard Basic	9 2 6	—
Intermediate Basic	8 12 6	—
Soft Basic	7 10 0	—
Hoops	12 0 0	—
Soft Wire Rods	9 5 0	—
Midlands—		
Small Rolled Bars	8 10 0 to 8 15 0	
Billets and Sheet Bars	7 0 0 to 7 5 0	
Sheets (20 W.G.)	11 10 0 to 12 0 0	
Galv. Sheets, f.o.b. L'pool	15 5 0 to 15 7 6	
Angles	7 15 0 to 8 0 0	
Joists	7 15 0 to 8 0 0	
Tees	8 15 0 to 9 0 0	
Bridge and Tank Plates	8 7 6	—
Boiler Plates	11 10 0	—

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14	19/6 to 19/9
Block Tin (cash)	303 10 0
,, (three months)	296 10 0
Copper (cash)	54 16 0
,, (three months)	55 7 6
Spanish Lead (cash)	26 18 9
,, (three months)	27 8 9
Spelter (cash)	29 12 6
,, (three months)	30 0 0
Manchester—	
Copper, Best Selected Ingots	61 0 0
,, Electrolytic	61 17 6
,, Strong Sheets	86 0 0
,, Tubes (Basis Price) lb.	0 1 0½
Brass Tubes (Basis Price) lb.	0 0 11½
,, Condenser lb.	0 1 1½
Lead, English	28 7 6
,, Foreign	27 10 0
Spelter	30 2 6
Aluminium (per ton)	£107

FERRO ALLOYS.

(All prices now nominal.)

	Per Ton.	Per Unit.
Tungsten Metal Powder	1/10½ per lb.	
Ferro Tungsten	1/5½ per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£23 0 0	7/6
,, ,, 6 p.c. to 8 p.c. ,,	£22 10 0	7/3
,, ,, 8 p.c. to 10 p.c. ,,	£22 7 6	6/6
,, ,, Specially Refined		
,, ,,Max. 2 p.c. carbon	£36 6	11/6
,, ,, ,, 1 p.c. ,,	£42 5 0	15/–
,, ,, ,, 0.70 p.c. carbon	£54 0 0	17/6
,, ,, ,, carbon free	1/5d. per lb.	
Metallic Chromium	3/3 per lb.	
Ferro Manganese (per ton)	£16 for home, £16 for export	
,, Silicon, 45 p.c. to 50 p.c.	£11 17 6 scale 5/– per unit	
,, ,, 75 p.c.	£19 0 0 scale 6/– per unit	
,, Vanadium	14/3 per lb.	
,, Molybdenum	5/– per lb.	
,, Titanium (carbon free)	0/11½ per lb.	
Nickel (per ton)	£170	
Cobalt	9/6 per lb.	

FUELS.

SCOTLAND.

(Prices not stable.)

	Export.
Lanarkshire—	
(f.o.b. Glasgow)—Steam	14/9
,, ,, Ell	15/3
,, ,, Splint	15/9 to 17/–
,, ,, Trebles	14/6
,, ,, Doubles	13/9
,, ,, Singles	13/6
Ayrshire—	
(f.o.b. Ports)—Steam	14/–
,, ,, Jewel	16/6
,, ,, Trebles	14/–
Fifeshire—	
(f.o.b. Methil or Burntisland)—Steam	12/9 to 14/6
Screened Navigation	21/–
Trebles	14/–
Doubles	13/6
Singles	13/6
Lothians—	
(f.o.b. Leith)—Best Steam	13/9
Secondary Steam	13/–
Trebles	14/–
Doubles	13/6
Singles	13/3

ENGLAND.

(8) N.W. Coast—	
Steams	27/6
Household	42/6 to 58/6
Coke	30/6
Northumberland—	
Best Steams	15/–
Second Steams	14/6
Steam Smalls	10/6
Unscreened	14/6 to 15/–
Household	21/– to 27/–
Durham—	
Best Gas	17/– to 17/6
Second	15/6 to 16/–
Household	21/– to 27/–
Foundry Coke	24/6 to 26/6

Sheffield—	Inland.	
Best Hand-picked Branch	34/–	
Best Selected House Coal	27/– to 29/–	—
Screened House Coal	23/– to 25/–	—
,, ,, Nuts	19/– to 21/–	—
Yorkshire Hards	18/– to 20/–	—
Derbyshire Hards	18/– to 20/–	—
Rough Slacks	11/– to 12/–	—
Nutty Slacks	8/– to 9/–	—
Smalls	3/– to 5/6	—
Blast-furnace Coke (Inland)	22/– to 27/6 at ovens.*	
,, ,, (Export)	f.o.b.	28/– to 30/–

(9) SOUTH WALES.

Cardiff—	
Steam Coals :	
Best Smokeless Large	23/– to 24/–
Second ,, ,,	22/6 to 23/–
Best Dry Large	21/– to 21/6
Ordinary Dry Large	20/– to 21/–
Best Black Vein Large	22/– to 22/6
Western Valley Large	21/6 to 21/9
Best Eastern Valley Large	20/– to 20/6
Ordinary ,, ,,	19/– to 20/–
Best Steam Smalls	14/3 to 14/9
Ordinary Smalls	13/– to 14/–
Washed Nuts	18/– to 22/–
No. 3 Rhondda Large	25/– to 26/–
,, ,, Smalls	16/6 to 17/–
No. 2 ,, Large	21/– to 21/6
,, ,, Through	18/– to 19/–
,, ,, Smalls	13/– to 14/–
Foundry Coke (export)	40/– to 45/–
Furnace Coke (export)	30/– to 32/6
Patent Fuel	26/– to 26/6
Pitwood (ex ship)	32/6 to 33/6
Swansea—	
Anthracite Coals :	
Best Big Vein Large	37/6 to 42/6
Seconds	32/6 to 35/–
Red Vein	27/– to 29/6
Machine-made Cobbles	42/6 to 47/6
Nuts	42/6 to 45/–
Beans	41/– to 43/–
Peas	21/6 to 23/–
Breaker Duff	8/6 to 9/6
Rubbly Culm	11/6 to 12/–
Steam Coals :	
Large	21/6 to 22/–
Seconds	19/6 to 21/6
Smalls	12/6 to 13/6
Cargo Through	17/– to 18/–

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/– extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. † Latest quotations available.

(a) Delivered Glasgow. (b) Delivered Sheffield. (c) Delivered Birmingham. * Open market price. Special price for pig iron producers, 22/– per ton at ovens.

French Engineering Notes.

(From our Correspondent in Paris.)

Steel and Concrete.

THE general use of concrete for building has reduced so considerably the consumption of girders that makers are arranging to carry out a propaganda in favour of structural steel, and it is mainly for that reason that the negotiations for the constitution of an international sales' organisation for girders are likely to be completed at an early date. The organisation will be placed under the direction of an expert specially qualified to popularise the use of steel joists and girders. The task should not be a particularly difficult one in view of the uneasy feeling that has been created from time to time by the collapse of concrete buildings under construction. The public is, of course, perfectly aware that the reliability of armoured concrete depends upon its quality and upon the manner of using it, but there is an impression that sufficient importance is not always attached to the value of expert knowledge in the making and use of concrete. This material became popular when steel prices rose to such a level that it was almost impossible to use steel for building purposes. Since then the margin has been considerably reduced by falling prices, and it is now observable that some big buildings in Paris and elsewhere are being constructed of steel. While armoured concrete has certainly come to stay, and will probably always be more economical in many cases, there is, nevertheless, no reason why the lower prices at which girders are now offered should not enable them to recover some of their lost ground. All other descriptions of rolled iron and steel are in small request, the only demand being for the execution of orders which are being given out by the State and the railway companies. These are particularly acceptable to locomotive and wagon builders who are in a better position than for years past. Contracts are being distributed for the ships to be built under the programme of naval construction during the coming year, and they are helping to alleviate the crisis; but, unfortunately, the general situation remains precarious.

Paris Suburban Traffic.

Since the suppression of the fortifications around Paris the city is extending so rapidly that the Conseil Supérieur des Chemins de Fer has found it necessary to investigate the means of providing suitable transport facilities in the future. A first step has already been taken by the electrification of the suburban lines, and the plan now suggested by the Conseil Supérieur is to extend this electrification to a radius of 25 miles and to join up the system with other lines so that any part of this area will be in easy communication with the direct electric trains to Paris. On account of the capital involved in the building and working of the suburban extensions, it is proposed to form a new company in which all the existing railway companies serving Paris and the road transport concerns will be represented. The work is urgent, as the suburban railway extensions and electrification can alone solve the problem of dealing with the steadily increasing population.

West African Railways.

The construction of the railway between Pointe-Noire, on the coast, and Brazzaville, on the Congo River, has passed through many vicissitudes and has encountered a good deal of opposition from those who criticised the route taken, but as nearly one-half of the line has been completed, there can be no question of its beng abandoned in favour of some other route. Out of a total length of 320 miles about 180 miles of railway are well advanced, and some of the sections are now in operation. Unfortunately, while the first section of the railway progressed satisfactorily across flat country a great deal of trouble was experienced when crossing the mountainous region of the Mayumbe, where the track had to be cut through forests and gorges, and the death roll amongst the native labourers was so high that the criticisms at home made it necessary for the Governor-General of Equatorial Africa to return to France and arrange for some other means to carry through the work. So far the transport has been effected entirely by porters, whose number greatly exceeded that of the men engaged on the construction of the railway. It has now been decided to accomplish it with the aid of motor vehicles, and special attention will be paid to the physical well-being of the native labourers. The French attach exceptional importance to the Pointe-Noire-Brazzaville Railway, as they believe that it will join up eventually with the proposed Belgian railway between Stanley Pool and Katanga, and will thus aid in draining traffic from Rhodesia, and will save a week as compared with the time now required for transport to Europe.

Commercial Agreements.

The interminable negotiations for renewing the temporary commercial arrangement between France and Germany afford some idea of the difficulties that will be experienced when France endeavours to enter into similar agreements with other countries. Germany refused to consider a permanent treaty until the French currency was stabilised and the new Tariff Bill was finally adopted. The difficulty lies in the fact that as France aims at producing everything for her own needs, and at exporting as much as possible, she seeks special favours for all her industries and has thus nothing to offer in return for concessions from other countries. After years of bargaining the French are beginning to see that if they would secure favours from foreign countries for essentially French products, they must attach less importance to the interests of subsidiary industries which aim at keeping out foreign goods. In the agreement just signed Germany undertakes to admit French wines during the next few months to the value of 48 million francs, while she will have the right to send into France manufactured goods and chemical products to the value of 60 million francs. France was obliged to make this concession on account of the necessity of finding markets for a huge surplus production of wine. In all other negotiations it will probably be found that facilities will be granted for the importation of foreign goods in return for concessions in favour of essentially French products.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

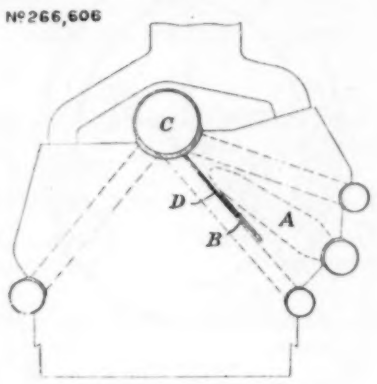
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

STEAM GENERATORS.

266,606. July 28th, 1926.—CONTROLLING SUPERHEAT, H. E. Yarrow, Scotstoun, Glasgow.

In this specification it is suggested that the degree to which the steam raised in a water-tube boiler is superheated, may be regulated by adjusting a damper or baffle in the way of the hot furnace gases. In the illustration the superheating tubes are

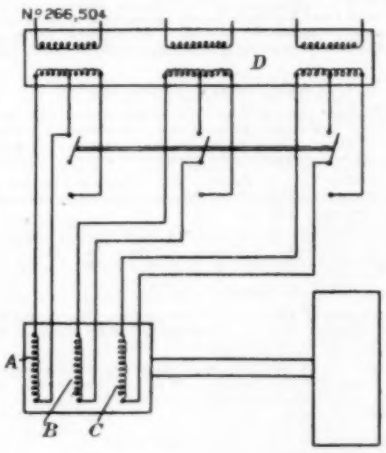


shown at A, and the baffle at B. This baffle is hung from the steam drum C by means of screwed rods D, and can be set at any appropriate position along the screwed length of the rods. It is suggested that the screws should be made of heat-resisting metal and screened, so far as is possible, from the action of the furnace gases.—*March 3rd*, 1927.

DYNAMOS AND MOTORS.

266,504. January 8th, 1926.—IMPROVEMENTS IN SYSTEMS OF CONTROLLING ELECTRIC MOTORS FOR STARTING SYNCHRONOUS MACHINES, Crompton and Co., Ltd., and Henry Ormsby Burge, both of Arc Works, Chelmsford.

This invention relates to improvements in systems of controlling electric motors for starting synchronous machines, and has for its object the reduction of the slip and the starting current of these motors. The induction motor is wound with three separate phases A B C, and the supply is taken from the secondary of a three-phase transformer D, also wound with three

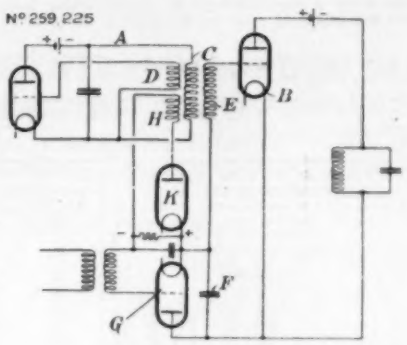


separate phases isolated from one another, the neutral point of each phase of the secondary being brought out as shown. By connecting each of the phases of the induction motor between one end of the transformer winding and the neutral point, half the full voltage may be applied at starting. To obtain the small slip necessary for synchronising, an excess voltage is then applied to the windings of the induction motor by transferring those ends of the windings of the induction motor, which were previously connected to the neutral points of the phases of the transformer, to the open ends of the transformer winding.—*March 3rd*, 1927.

TELEGRAPHS AND TELEPHONES.

259,225. September 30th, 1926.—IMPROVEMENTS IN OR RELATING TO RADIO TRANSMITTERS, Telefunken Gesellschaft für drahtlose Telegraphie m.b.H., of 9, Tempelhofer Ufer, Berlin, Germany.

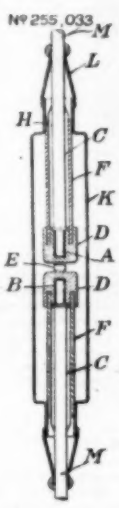
The object of this invention is to provide a valve transmitter in which an automatically varied bias potential dependent upon the grid voltage of the main transmitter is applied to the modulation valve. A is a control transmitter and B a separately controlled main transmitter. The control transmitter is reaction coupled through a coil C in the oscillation circuit and coil D in the grid circuit, and controls the main transmitter through the coil E. Parallel with the grid condenser of the main transmitter is the modulation valve G, upon the grid circuit of which the grid voltage obtained by rectification of high-frequency energy taken from the control circuit by way of the coil H is impressed. K is a rectifying valve by means of which the high-frequency energy is rectified, the direct-current voltage being brought to a resistance-shunted condenser in the grid circuit of the modulation valve. The arrangement has the advantage that when a diminution of high-frequency energy occurs in the



control transmitter, the grid voltage of the modulation valve falls, and if accurately adjusted the modulation valve operates over the best part of its working characteristic.—*March 3rd*, 1927.

TRANSMISSION OF POWER.

255,033. June 12th, 1926.—IMPROVEMENTS IN OR RELATING TO JOINTS FOR HIGH-TENSION ELECTRIC CABLES, Pirelli and Co., of Bicocca Works, near Milan, Italy.

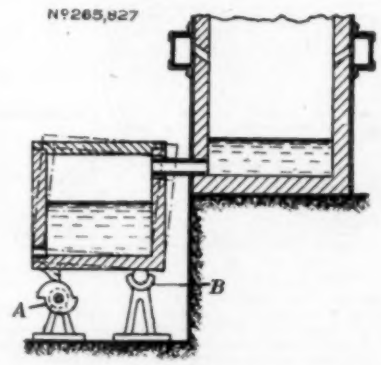


The two adjacent sections of the cable to be joined in accordance with this invention are shown at A and B. The paper C is removed from the ends of the conductors which are then inserted in metal blocks D, united by a flexible conductor E, such as a spring, the ends of which are soldered to provide good electrical connection. Each block is furnished with a recess or socket for the reception of a tube F of insulating material. By making the blocks separate and uniting them by a flexible connector, each block is capable of slight movement, with respect to the other, thus preventing stress on the insulating tables which might cause them to crack. Between the tubes and the conductors is a space H, which is filled with light insulating oil. Surrounding the parts is a casing K, usually made of brass. At the ends of the casing there is a thimble L, the outer end of which is secured to the lead sheath M of the cable, as, for example, by a wiped joint. The spaces between the tubes F, thimbles M and the conductors are filled with thin oil, which may be supplied directly from the core of the conductors or from suitable reservoirs.—*March 3rd*, 1927.

FURNACES.

265,827. May 14th, 1926.—CUPOLA FURNACES, J. Dechesne, 4, Lloydstrasse, Rostock, Germany.

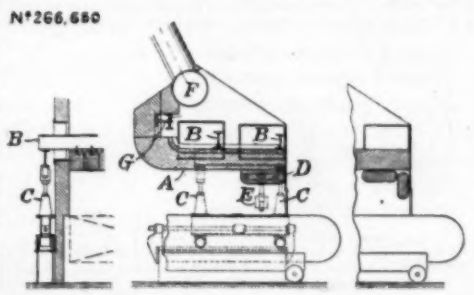
The inventor aims at improving the product of a cupola by tapping it into a forehearth and there stirring up the charge



mechanically, so that the gases and slag may be thoroughly liberated. This stirring is effected by jolting the forehearth up and down by means of the cam A. It will be seen that the hearth rocks about the pivot B.—*February 17th*, 1927.

266,650. December 17th, 1926.—ADAPTABLE FURNACE ARCHES, H. E. Yarrow, Scotstoun, Glasgow.

This invention is concerned with the adaptation of the furnace



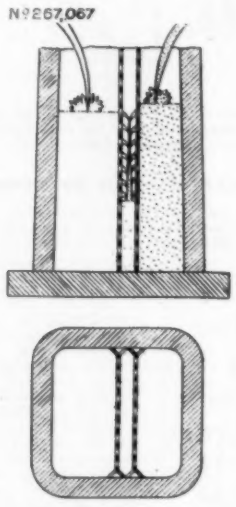
of a water-tube boiler to widely varying demands, by means of increasing the head room over the grate. For this reason the furnace arch A is supported by means of steel girders, such as

those shown at B B, which are carried by jacks C outside the boiler casing. The ignition arch D is also carried by separate jacks E, so that it may be adjusted in turn. The movement of the arch with respect to the fixed part round the water drum F of the boiler is accommodated by loosely fitting bolts G.—*March 3rd*, 1927.

METALLURGY.

267,067. February 5th, 1927.—Casting Compound Ingots, Klöckner-Werke A.G., Abteilung Georgs-Marien-Werke, Osnabruck, Germany.

This invention is concerned with the production of compound steel ingots, having the two parts of different compositions. The chill in which the ingot is poured is divided by a double partition of perforated metal. As the two compartments are filled with the two qualities of molten steel, jets of the steels issue from the perforations, and in falling are slightly cooled,

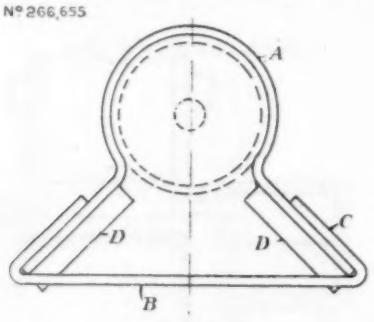


so that the central portion sets first and prevents the two main bodies of steel from comingling. A further characteristic of the invention consists in the special formation of the edges of the sheets of the separating walls, which are provided with divergent tongues, whereby an abrupt straight juncture of the contiguous masses of steel is prevented. At the same time, a simple resilient fastening of the plates within the chill is realised by means of this formation of the edges of the sheets.—*March 10th*, 1927.

MISCELLANEOUS.

266,655. January 21st, 1927.—Identification Label for Insulated Conductors, Heinrich Bokelmann, of 19, Turinerstrasse, Berlin, Germany; and Hans Gastrow, of 3, Milinowskistrasse, Zehlendorf, Germany.

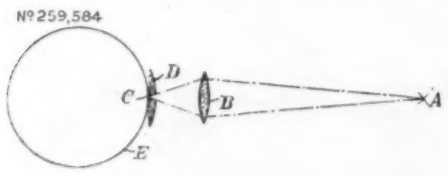
In switchgears and power stations an easily recognisable and clear identification of the numerous measuring, controlling and signalling conductors forms an important basis for the rapid repair of any breakdowns that may occur. According to this invention, a clip A similar in shape to the Greek letter Ω is laid



around the conductor and compressed to such an extent that the label B, which has the identification mark of the conductor clearly stamped upon it, on a coloured background for the indication of the phase, can be pushed over it. The bent-over lugs C of the label engage the arms of the clip and the stops D formed by bending over one edge of the clip serve to limit the extent to which the label can be pushed on to the clip. The conductor label is thus fixed firmly in position on the wire and, even though the wire be detached from its terminal, the label cannot fall off. —*March 3rd*, 1927.

259,584. October 6th, 1926.—Improvements in or relating to Picture and the like Telegraphy, Telefunken Gesellschaft für drahtlose Telegraphie, m.b.H., of 9, Tempelhofer Ufer, Berlin.

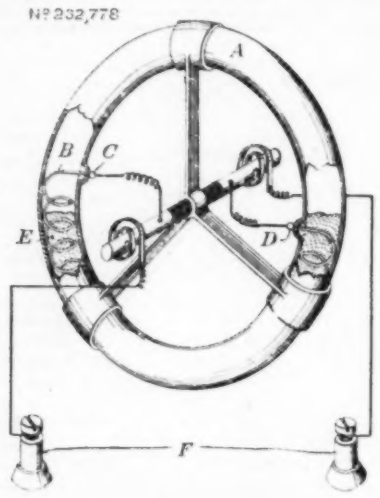
The object of this invention is to provide apparatus whereby a picture may be telegraphed direct from a non-transparent



picture. Light leaving the point form source of light A is concentrated by means of the lens B and projected upon a point C on a drum carrying a picture E, and meeting either a light or dark point of the picture is reflected diffusedly more or less strongly. The photo-electric cell D is arranged as near as possible to the point C, and in such a manner that it allows the original beam of light to pass through from the back, the light-sensitive side of the cell intercepting the diffused reflected light as completely as possible. The light-sensitive cell is preferably of ring formation with a small inner diameter and a large outer diameter, and the surface of the cell is preferably adapted to conform to the curved picture surface. The invention may employ any desired type of photo-electric cell—for example, selenium or vacuum photo cells. In the latter case, either the entire vacuum tube or the light-sensitive layer only may be of ring formation, in which case the light passes through a transparent portion, substantially at the centre of the layer. The principal advantage claimed for the invention is that it enables an "original" picture, which need not be transparent, to be transmitted.—*March 10th*, 1927.

262,778. December 7th, 1926.—Improvements in or relating to Regulatable Resistances, Siemens and Halske Aktiengesellschaft, of Berlin-Siemensstadt, Germany.

This specification describes a resistance characterised by the fact that a resistance wire is spirally arranged in a hollow ring of insulating material, and upon displacement of the ring the wire can be wholly or partially short-circuited by mercury. The hollow ring A is made of glass, and the coil B is composed of resilient material, the ends being brought out at the points C



and D. The coil of wire bears upon the inner walls of the ring, and is thereby well secured in position. In the ring there is mercury, as shown at E, which in the position shown covers the resistance wire almost completely, so that for the most part it is short circuited. By turning the hollow ring about its axis, the length of the part of the resistance short circuited by the mercury can be regulated. The method of connecting the spiral resistance to the terminals F is self-explanatory.—*March 3rd*, 1927.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.

WEDNESDAY, APRIL 20TH.

Institution of Automobile Engineers.—Chamber of Commerce, New-street, Birmingham. Birmingham Graduates' meeting. Paper, "Brakes," by Mr. K. K. Trimbee. 7.30 p.m.

Newcomen Society.—Prince Henry's Room, 17, Fleet-street, London, E.C. 4. Paper, "Marc Seguin and the Invention of the Tubular Boiler," by Messrs. Ferdinand Achard and Laurent Seguin. 5.30 p.m.

Royal Meteorological Society.—49, Cromwell-road, South Kensington, London, S.W. 7. Discussion on "The Range of Atmospherics," opened by Mr. R. A. Watson Watt. 5 p.m.

THURSDAY, APRIL 21ST.

Institution of Automobile Engineers.—Watergate House, Adelphi, London, W.C. 2. London Graduates' meeting. Paper, "Repairs," by Mr. W. G. Ruggins. 7.30 p.m.

Institution of Electrical Engineers.—Savoy-place, Victoria Embankment, London, W.C. 2. Eighteenth Kelvin Lecture on "High-frequency Currents," by Professor E. W. Marchant. 6 p.m.

FRIDAY, APRIL 22ND.

Institution of Mechanical Engineers.—Storey's Gate, Westminster, London, S.W. 1. Informal meeting. "The Engineering of Distribution, with Special Reference to Finance as a form of Organisation," introduced by Major C. H. Douglas. 7 p.m.

Junior Institution of Engineers.—39, Victoria-street, London, S.W. 1. Paper, "Shock Absorber Units for Land Planes," by Mr. C. D. Holland. 7.30 p.m.

SATURDAY, APRIL 23RD.

Institution of Automobile Engineers.—London Graduates' visit to the London and North-Eastern Railway Works, Stratford, E. 15. 2.30 p.m.

Institution of Municipal and County Engineers.—County Hall, Ipswich. Eastern District meeting. 10.45 a.m.

MONDAY, APRIL 25TH.

Chemical Engineering Group.—American Film Company, Ltd., 89–91, Wardour-street, London, W. 1. Paper, "Permanent Moulding Machines for Cast Iron," by Professor J. W. Hinchley. 8 p.m.

Institution of Mechanical Engineers.—Storey's Gate, Westminster, London, S.W. 1. Graduates' Section meeting. "Parcel and Package Conveying Plant," by Mr. H. W. Cadman. 7 p.m.

Railway Club.—25, Tothill-street, London, S.W. 1. Debate, "That the Grouping of British Railways has not been Beneficial." 7.30 p.m.

TUESDAY, APRIL 26TH.

Illuminating Engineering Society.—National Physical Laboratory, Teddington. Inspection of the Photometric Section of the Laboratory. Paper, "Work in the Photometry Department of the National Physical Laboratory," by Mr. H. Buckley. 7 p.m.

Junior Institution of Engineers.—Monico Restaurant, Shaftesbury-avenue, London, W. 1. Annual dinner. 6.30 p.m.

WEDNESDAY, APRIL 27TH.

Royal Society of Arts.—John-street, Adelphi, London, W.C. 2. "Fire Waste (*Loss* of Property by Fire) and its Effects on the Economics of National Life in Great Britain," by Mr. G. E. Keay. 8 p.m.

THURSDAY, APRIL 28TH.

Institute of Metals: London Local Section.—Society of Motor Manufacturers and Traders, 83, Pall Mall, London, S.W. 1. Annual general meeting. Discussion on "The Working of Metals," opened by Mr. E. I. Thorne. 7.30 p.m.

Institution of Structural Engineers.—10, Upper Belgrave-street, London, S.W. 1. Debate, "That the System of Education of Structural Engineers by Articled Pupilage is Contrary to the Best Interests of the Student, and should be Superseded by Education in Recognised Engineering Schools." 8 p.m.

Royal Meteorological Society.—49, Cromwell-road, South Kensington, London, S.W. 7. Address by Sir Samuel Hoare on his recent flight to the East. 5.30 p.m.

FRIDAY, APRIL 29TH.

Diesel Engine Users Association.—Caxton Hall, Westminster, London, S.W. 1. Paper, "Further Developments in Mechanical Injection Oil Engines," by Mr. Oswald Wans.

Institute of Metals: Swansea Local Section.—Metallurgical Department of the University College, Singleton Park, Swansea. Annual general meeting. 7.15 p.m.

Institution of Electrical Engineers: Scottish Centre.—Technical College, Bell-street, Dundee. Paper, "Modern Electrical Wiring, particularly as Applied to Small Houses," by Mr. D. S. Munro. 7.30 p.m.

Institution of Engineering Inspection.—Royal Society of Arts, John-street, Adelphi, London, W.C. 2. Paper, "The Stress-strain Diagram and its Application to the Testing of Rolling Stock Draw Gear," by Mr. L. H. Evans. 7.30 p.m.

Institution of Mechanical Engineers.—Storey's Gate, Westminster, London, S.W. 1. Paper, "The Failure of Some Steel Wires Under Repeated Torsional Stresses at Various Mean Stresses," by Professor F. C. Lea and Mr. F. Heywood. 6 p.m.

Junior Institution of Engineers.—39, Victoria-street, London, S.W. 1. Paper, "The Design and Balancing of Three-phase Low-tension Distribution Systems," by Mr. W. Fordham Cooper. 7.30 p.m.

Royal Institution of Great Britain.—21, Albemarle-street, London, W. 1. Discourse, "Wireless Transmission and the Upper Atmosphere," by Dr. E. V. Appleton. 9 p.m.

THURSDAY AND FRIDAY, MAY 5TH AND 6TH.

Iron and Steel Institute.—Institution of Civil Engineers, Great George-street, London, S.W. 1. Annual meeting. For programme see below. 10 a.m. each day.

Empire Sugar.—A meeting was held on the 7th inst. of the Empire Section of the British Empire Producers' Organisation, which represents the entire sugar producing industry of the British Empire, at which it was unanimously decided to constitute the Section into a Federation, the membership of which will include the producers and refiners of the sugar industry and all others interested in the production, transport and marketing of Empire sugar. The objects of the Federation are to promote the interests of the sugar industry of the Empire and to collect information regarding all matters relating to methods of production, transport and marketing; to carry out a programme of propaganda and publicity with a view to increasing the production, sale and consumption of Empire sugar and to obtain such treatment for Empire-produced sugar as will secure stability and generally to take such action as may be considered desirable in the interests of the Empire sugar industry. This central organisation has been rendered necessary not only to improve the internal methods of the industry and to increase production within the Empire, but also to be able to confront as a united body the highly organised competition of European and American producers and refiners. Mr. Ben H. Morgan was unanimously elected as chairman of the new body. He has for the past six years acted as Chairman of Council of the British Empire Producers' Organisation.

Iron and Steel Institute.—The annual meeting of the Iron and Steel Institute will be held at the Institution of Civil Engineers, Great George-street, Westminster, on Thursday and Friday, May 5th and 6th, 1927, commencing each day at 10 a.m. The following is the programme of proceedings:—*Thursday, May 5th.*—10 a.m., presentation of annual report and statement of accounts for 1926; election of new members; induction of newly elected President, Mr. F. W. Harbord, C.B.E., into the chair; presentation of Bessemer Gold Medals to Mr. Axel Wahlberg and Professor C. Benedicks; presidential address; presentation of the following papers for discussion:—J. Seigle, "Some Aspects of the Technical and Economic Conditions of the Heavy Metallurgical Industry of the East of France, with Particular Reference to the Utilisation of Gases and Motive Power;" W. A. Bone, L. Reeve, and H. E. Saunders, "An Experimental Inquiry into the Interactions of Gases and Ore in the Blast-furnace;" 2.30 p.m., presentation of the following papers for discussion:—Sir Robert Hadfield, "The Metal Manganese and its Properties; also the Production of Ferro-manganese and its History;" Sir Robert Hadfield, "Low-carbon Alloys of Iron and Manganese;" W. Rosenhain, "Alloys of Iron Research:" Introductory, by W. Rosenhain: Part V., Preparation of Pure Chromium, by F. Adcock; Part VI., Preparation of Pure Manganese, by Marie L. V. Gayler; Part VII., Preparation of High Purity Silicon, by N. P. Tucker; J. L. Haughton, "Alloys of Iron Research, Part VIII., the Constitution of Alloys of Iron and Phosphorus;" 7.30 p.m., annual dinner of the Institute in the Grand Hall, Connaught Rooms, Great Queen-street, W.C. *Friday, May 6th.*—10 a.m., announcement of the award of the Andrew Carnegie Research Scholarships for 1927–8; presentation of the following papers for discussion:—E. A. Atkins, "The Drawing of Steel Wire and its Relation to Qualities of Steel;" W. H. Hatfield, "Heat-resisting Steels;" C. A. Edwards and J. C. Jones, "The Influence of Annealing Temperature on the Properties of Mild Steel Sheets;" T. Swinden and G. R. Bolsover, "Some Notes on Cold-rolled Strip Steel;" if time permits: B. Yaneske, "The Manufacture of Steel in India by the Duplex Process;" 2.30 p.m., presentation of the following papers for discussion:—C. Benedicks and H. Löfquist, "Theory of the Growth of Cast Iron Repeatedly Heated;" J. H. Andrew and H. A. Dickie, "The Ac_1 Range in Special Steels;" J. H. Andrew, M. S. Fisher and J. M. Robertson, "The Properties of Some Nickel-chromium-molybdenum Steels;" "if time should not permit of the reading and discussion of the following papers, they will be taken as read and discussion by correspondence will be invited: K. Honda and K. Takahasi, "A Further Investigation of the Indentation Hardness of Metals;" T. Matsushita and K. Nagasawa, "The Phenomenon of Temper Hardening in Steels;" S. Tamura, "Notes on Pseudo-twinning in Ferrite, and on the Solubility of Carbon in Alpha Iron at the A_1 Point."